"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS MASONS AND BUILDERS GUIDE #2

A PRACTICAL ILLUSTRATED TRADE ASSISTANT ON

MODERN CONSTRUCTION

FOR BRICKLAYERS-STONE MASONS CEMENT WORKERS-PLASTERERS AND TILE SETTERS

EXPLAINING IN PRACTICAL, CONCISE LANGUAGE AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS CHARTS, GRAPHS AND PICTURES, PRINCIPLES ADVANCES, SHORT CUTS-BASED ON MODERN PRACTICE-INCLUDING INSTRUCTIONS ON HOW TO FIGURE AND CALCULATE VARIOUS JOBS

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Foreword

"The Audel's Guides to the Building Trades" are a practical series of educators on the various branches of Modern Building Construction and are dedicated to Master Builders and their Associates.

These Guides are designed to give technical trade information in concise, accurate, plain language.

The Guides illustrate the hows and whys, short cuts, modern ways and methods of the foundation principles of the art.

Each book in the series is fully illustrated and indexed for readiest form of reference and study.

The Guides will speak for themselves—and help to increase the reader's knowledge and skill in the Building Trades.

—*Publishers.*

OUTLINE OF CHAPTERS

How to Use the Guides

When using the Guides as *instruction* books, map out a course of study by consulting the table of contents in each volume: when using them as a reference work, consult the index.

1. Read the index and look up items you do not understand.
2. Review the portions of text you find difficult to understand.
3. Do not be satisfied in memorizing a rule or formula: *understand* the principle upon which it depends.
4. It is better to understand the basic principle of any rule or formula, than to trust to memory.
5. Studying without system is like a ship at sea without a rudder.
6. Do not get into the habit of reading, and thinking about something else at the same time.
7. Read the text and ***concentrate*** upon what you are reading.
8. If you ***will concentrate completely*** on the text matter you may find that ***one reading is all that is needed.***
9. After studying a section of the text, make a list of questions covering the subject treated, and review the text till you can answer all the questions.
10. Study each step thoroughly and review it before going on to the next.
11. Master one subject before you take up another.
12. Study when the mind is clear and you are rested; it is difficult to concentrate when tired.

WHEN TO DO YOUR READING

Read on trains, street cars, lunch hours and use the Guides constantly for reference. You can easily find 30 minutes each day for this important work. It is well to study at stated times and keep up the practice until it becomes a habit.

READY REFERENCE INDEX

A

B

T

U

V

W

CHAPTER 74

Arches

Mathematically an arch is *any bowlike curve,* but to the bricklayer it is *any structure supported at the sides or ends only and formed of distinct pieces no one of which spans the opening, serving to carry downward pressure and transform it into lateral thrust.*

A pure brick arch is formed of brick all precisely similar and has its inner and outer curves concentric and free from any projectures, such an arch within certain limits is elastic and will adjust itself without showing to irregularities of pressure.

In the study of arches the student should become familiar with the technical terms used, a list of which is here given for ready reference.

List of Arch Terms

Abutments. Parts of wall supporting the arch and from which the arch springs.

Crown. The highest point of the arch.

Extrados. The outer or upper surface of the arch, sometimes called the back.

Haunch. The middle part of each side of the arch, *i.e.* midway between the skewback and the crown.

Intrados or Soffit. The under surface of the arch.

Jambs. The sides of piers or abutments.

Key. The uppermost, central and what should be the last brick or voussoir in the arch.

Rise. Vertical distance between the highest point of the intrados from the level of the springing points.

Piers. Parts of wall supporting arches, from two or more sides of which arches spring.

Span. Horizontal distance between the springing points.

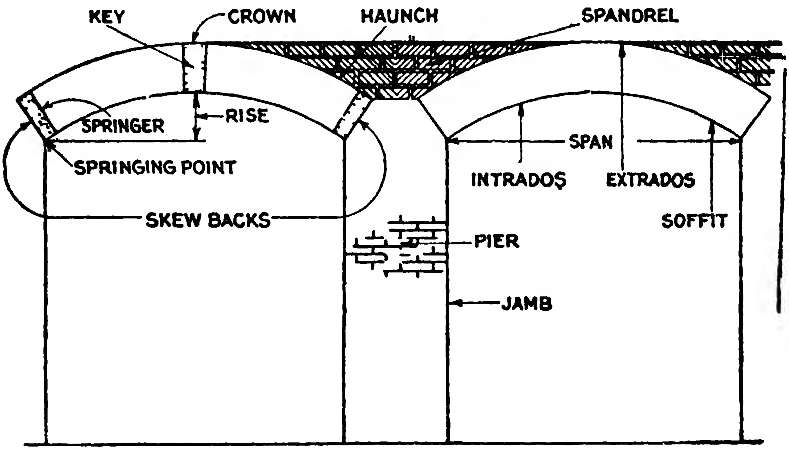


FIG. 4,302.—Two arches springing from a common pier illustrating definitions.

Spandrel. The spaces between the level of the crown and the extrados of the arch.

Skewbacks. The upper surfaces of the abutments or piers from which an arch springs.

Springers. The end or lowest bricks in the arch.

Voussoirs. The bricks or stones which make up the arch.

Springing points. Points from which the under curves of the arch commences.

These terms are illustrated in fig. 4,302. Arch construction involves three separate operations:

1. Laying out.
2. Building temporary supports.
3. Laying the brick.

In flat or so called arches no laying out is necessary, but for curved arches, the curves specified by the architect must be "laid out" or scribed full size on the lumber to be used as temporary supports. Directions for doing this and laying the brick are given below.

Classification of Arches.—There is a multiplicity of arch types, all of which may be grouped under a few heads. Arches may be classed:

1. With respect to shape, as
   - *a.* Flat or jack
   - *b.* Curved. { segmental, semi-circular, elliptical, pointed
2. With respect to kind of brick used, as
   - *a.* Ordinary.
   - *b.* Special.
3. With respect to position, as
   - *a.* Upright.
   - *b.* Inverted.
4. With respect to treatment of the brick, as
   - *a.* Plain.
   - *b.* Gauged.
   - *c.* Rough axed or cut.

5. With respect to brick courses, as

   a. Ordinary or parallel.
   b. Dutch or diagonal.

6. With respect to the method of laying the brick, as

   a. Flat.
   b. On edge.
   c. Soldier.

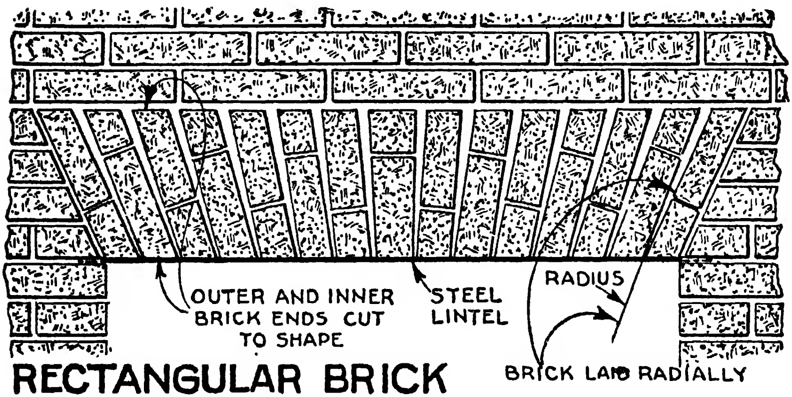


FIG. 4,303.—Flat arch with *standard brick*, an inexpensive type of arch, the bricks are not wedge shape, mortar being used to fill the converging joints. The thick end forming the extractor and intractor should be shaped so as to lie in horizontal places.

Flat, segmental, semi-circular and elliptical arches are commonly used. In the latter type a more pleasing outline may be obtained by laying out the curve freehand than by using a true ellipse constructed mechanically. A true ellipse has too great a radius at the spring line.

The Flat Arch.—Although, in theory, a flat or "jack" arch is a true arch, capable of bearing a load, in practice it is weak and should be supported on steel if the opening is over two feet

wide. The steel should of course be bent to the camber, if any, of the soffit.

If the very best effect be desired, jack arches should be constructed so that the radial joints are the same width for the whole length of the joint. To make a perfect job, either special brick must be made or the bricks rubbed to a wedge shape.

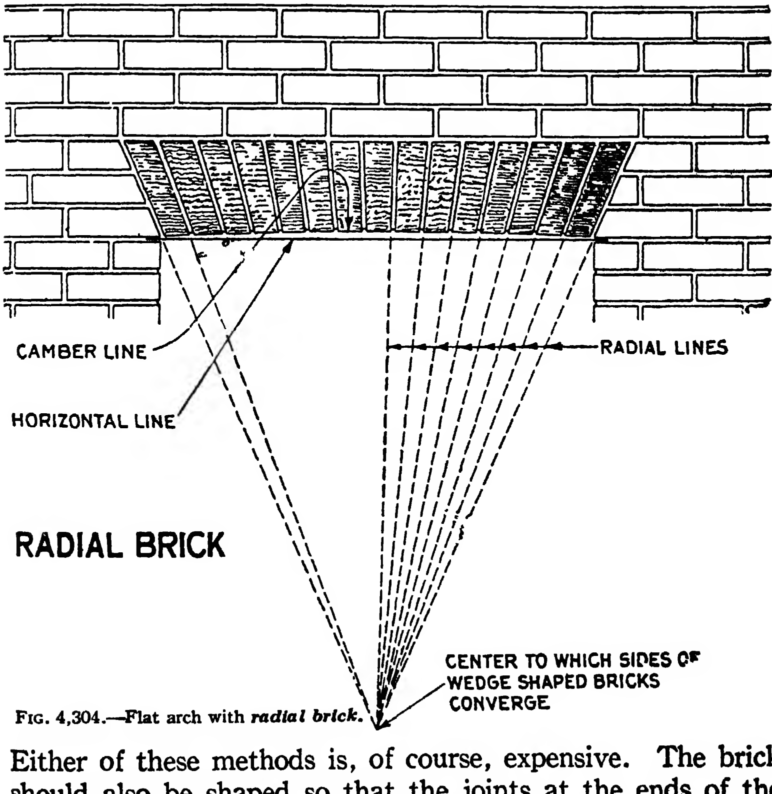
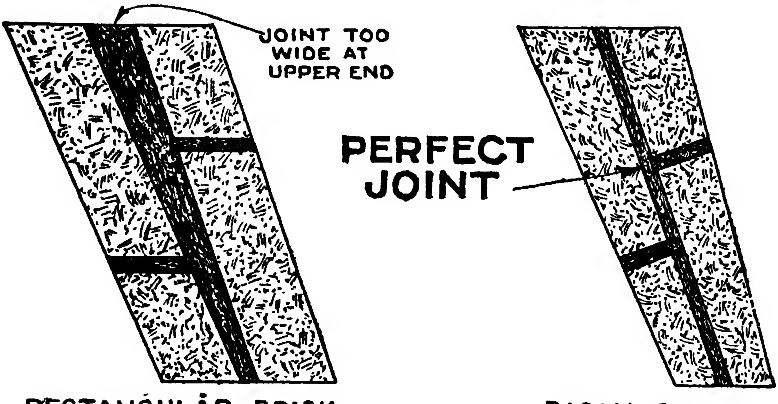


FIG. 4,304.—Flat arch with *radial brick*.

Either of these methods is, of course, expensive. The brick should also be shaped so that the joints at the ends of the brick within the arch are horizontal, instead of at right angles to the radius of the arch, as in fig. 4,303.

Inasmuch as a perfectly horizontal soffit, especially a wide one, appears to the eye to sag in the middle, a slight camber may be formed in the soffit to correct this, as shown in fig. 4,304, which illustrates the better type of flat arch made with special radial brick.

Laying Out a Flat Arch.—For proper construction, flat arches as well as curved arches should be first laid out in order to determine the proper placement of the brick—their number and

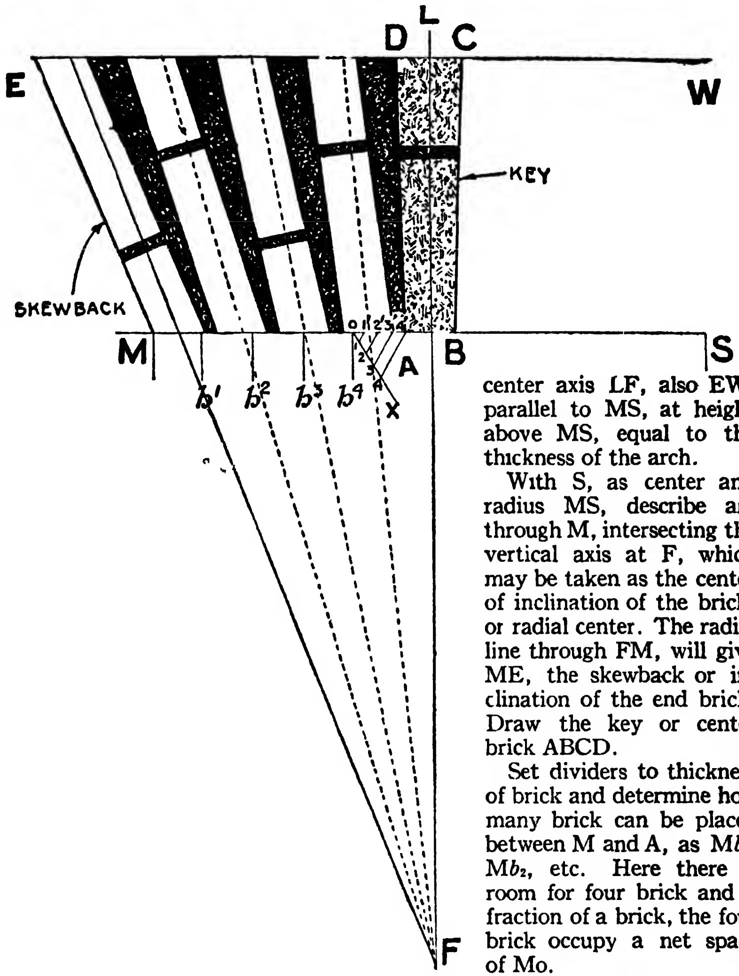


FIGS. 4,305 and 4,306.—Detail of joint obtained with rectangular and radial brick. With radial brick, the larger mortar is the same thickness the entire length of joint giving better results both as to appearance and strength.

inclination, the latter especially when rectangular brick are used. The problem of laying out these involves determining:

1. Number of brick to span the opening.
2. Center of inclination.

The method of laying out a flat arch is shown in fig. 4,307.. Here let MS be the span. Bisect MS, and through the point of bisection draw vertical



center axis LF, also EW, parallel to MS, at height above MS, equal to the thickness of the arch.

With S, as center and radius MS, describe arc through M, intersecting the vertical axis at F, which may be taken as the center of inclination of the brick, or radial center. The radial line through FM, will give ME, the skewback or inclination of the end brick. Draw the key or center brick ABCD.

Set dividers to thickness of brick and determine how many brick can be placed between M and A, as Mb_1, Mb_2, etc. Here there is room for four brick and a fraction of a brick, the four brick occupy a net space of Mo.

FIG. 4,307.—Layout for flat arch showing method of finding radial center (ordinary length) and of determining number of standard rectangular brick.

Divide the remaining distance OA, into four equal parts by the familiar construction, that is, drawing OX, at any angle to OA; space off four equal

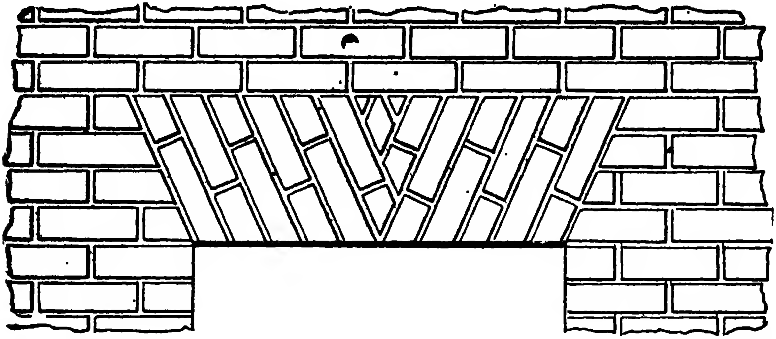
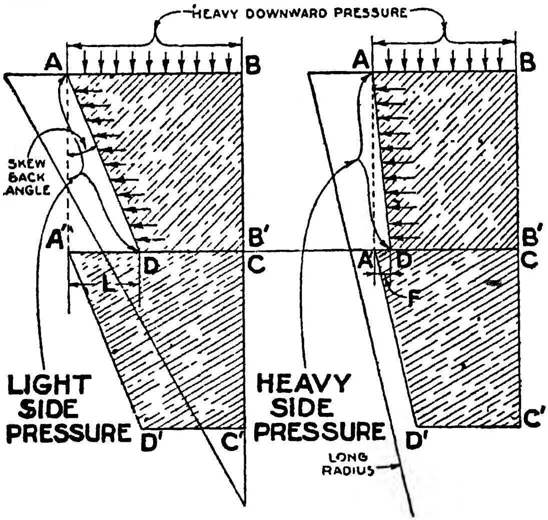


FIG. 4,308.—Dutch type of flat arch. This arch is quickly constructed and is frequently used over surfaces which are to be plastered. It is however considered relatively weak



FIGS. 4,309 and 4,310.—Relation between length of radius and lateral thrust against the skew backs. If in fig. 4,309, with short radius a sufficiently heavy pressure be applied on section A,B,C,D, as to push it vertically down to points A',B',C ,D', the skew back would be pushed back a distance L. Similarly in fig. 4,310, with long radius, the skew back is pushed back a distance F, which is less than L, giving, as must be evident, more leverage than in fig. 4,309. In other words since the pressure applied and distance section A,B,C,D, moves the same in each case, the work done is the same, hence the resistance overcome is less in fig. 4,309 than in fig. 4,310, being in the proportion of F to L; that is *it varies inversely with the sine of the skew back angle.*

divisions 01, 12, etc. on OX; join 44′ and draw parallels giving 01′, 02′, etc.; the 01′ is the thickness of mortar joint at the bottom or intradoor which must be provided so that the brick and joints will fill the space from skew-back to key.

The position of the center F, varies greatly depending upon the architectural effect sought, and what is more important—upon the strength.

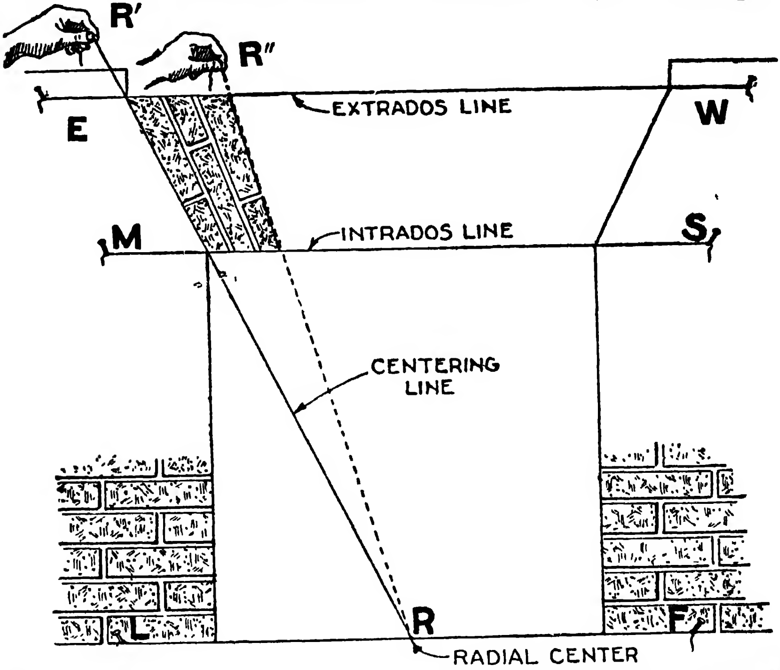


FIG. 4,311.—Lines for flat arch. Stretch between nails driven in the masonry, the extrados and intrados lines **EW** and **MS**, and locate radial center on line **LF**, attached at the proper level. Another line **RR′** is attached to R, and used as a centering line for which the proper inclination of the brick at various points is easily determined by moving the centering line to any intermediate position as **RR″**.

In the latter respect the length of inclination radius *must* be short for weak anchorage and may be long for strong anchorage as shown in figs. 4,309 and 4,310.

Having laid out the arch, the bricklayer transfers from the

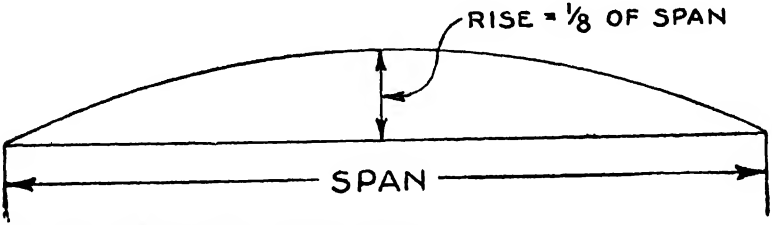


FIG. 4,312. —A good proportion for a segmental arch.

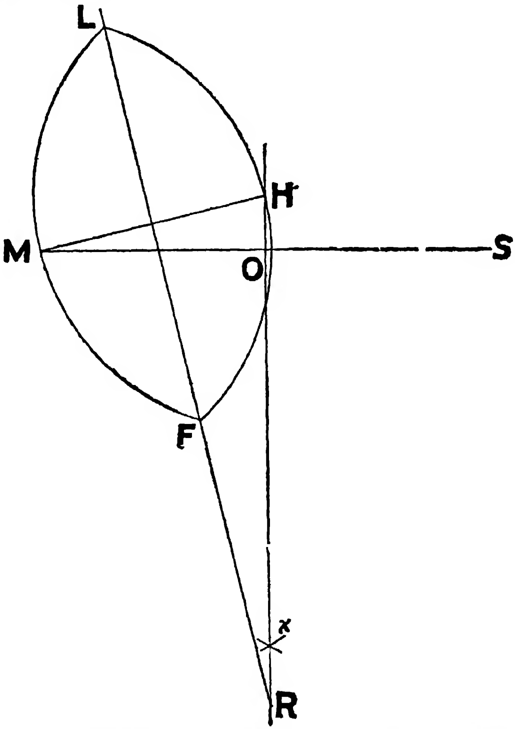
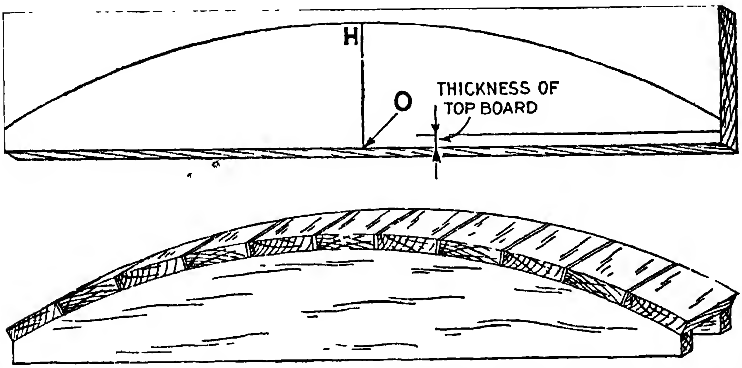


FIG. 4,313.—Layout for segmental arch *Given* M S, span and O H, rise. At the point O, midway between M S, erect a perpendicular H Ox, by describing thus M and S, with the same radius arcs intersecting at x Join M H, and describe through M and H, as centers, with the same radius, arcs intersecting at L and F. A line drawn through L and F, will cut the perpendicular Hx at R, which is the center of the arc.

drawing to the walls the principal items, radial center boundaries of arch, using lines as shown in fig. 4,311.

Segmental Arches.—The strongest type of arch is the segmental, where the abutment is ample to resist the thrust. With small abutments the semi-circular arch is safer.

For openings over windows and doors in residences the segmental arch is the type almost always used. The rise of a



Figs 4,314 and 4,315 —Arch curve laid out on board for temporary support, and the latter completed

segmental arch will of course depend on the architectural design. A good rule to follow, however, is to make the rise equal to one-eighth the width of the opening, as shown in fig. 4,312.

In constructing a segmental arch, first, supports having the proper curvature must be made, hence the center of the arch (having given the span and rise) must be located as in fig. 4,313.

Relieved Segmental Arch.—This is a combination of segmental arch, lintel and filler as shown in fig. 4,317. It is used for the purpose of *relieving* (hence the name) the weight from any portion of the building which is too weak to bear it, and

discharging or transmitting it to piers, especially prepared to take the load. The most frequent use for the relieving arch is inside the building, over door and window openings.

The opening is first bridged by the lintel, which should rest not less than 4½ ins. upon the jambs each side of the opening.

Next a brick core or filler is built throughout the entire length of the lintel to serve as a turning piece for the arch, the curve conforming to the curve of the arch obtained as previously explained. The curve for the core is obtained by means of a curved template having the same rise as

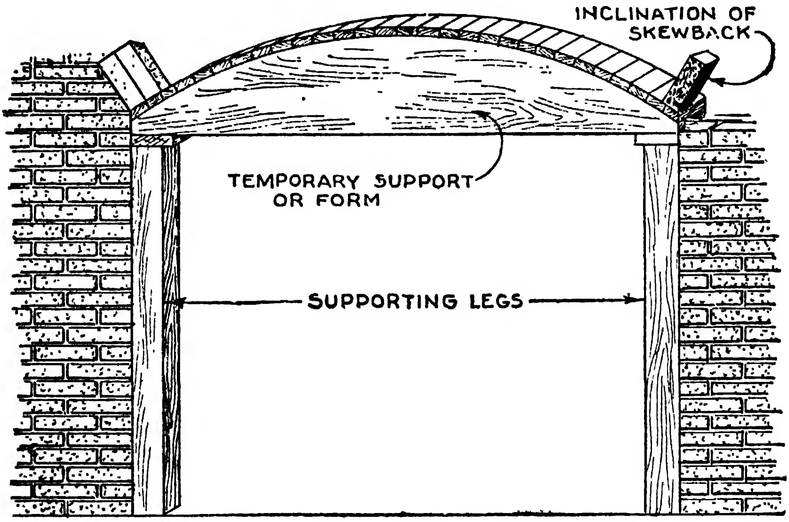


FIG. 4,316.—Temporary support in position in opening for arch and method of determining inclination of skew-back, the usual practice is to stand a brick on its end at the end of the support. The side of the brick then being in a radial direction will give the inclination or angle of the skew-back.

the arch. This is applied to the face of the core, the bricks marked and then cut to shape. The core acts simply as a filler.

Should a fire occur the lintel would burn and the core fall, but the arch ought to remain.

For relieving arches and for arches in basements the rise from spring line to soffit may be made one inch for every foot of opening. In the very

best work, the bricks in segmental arches where rowlocks are 9″ wide are rubbed to wedge shape, but for ordinary residence work the curve is taken up in joints, by making them wider at the top than the bottom. Bricks are sometimes chipped to wedge shape by the bricklayer. The strongest arches are bonded by headers, as in the case of a brick wall.

Semi-Circular Arch.—This arch, usually called a "semi," is similar in layout and construction to the segmental arch: instead of inclined skewbacks, the arch springs from horizontal surfaces each side of the opening, as shown in fig. 4,318.

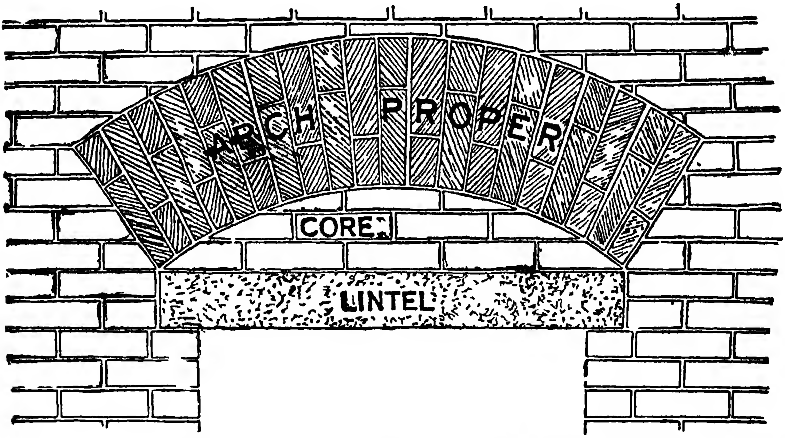


FIG 4,317.—Relieved segmental arch consisting of lintel, core or filler, and relieving arch or arch proper.

The laying out is simple; the center lying on the line joining the springing points M and S. The semi-circular arch is perhaps the strongest for general purposes that can be constructed. It is usually built of successive rings of brick laid on their edge. The temporary support is constructed as shown in fig. 4,319, the construction being similar to that used for the segmental arches.

When semi-circular arches are constructed of common brick,

the brick are laid close together on the inner edge or intrados with wedge shaped joints in the outer edge or extrados, that is, the mortar joints are wider at the upper surface of the brick ring than at the lower surface, so that there is more mortar at the top of the joint than at the bottom. The bed surfaces of the brick are therefore not on radial lines, as they are in a gauged brick arch, but the radial lines are assumed to pass through the center of each mortar joint.

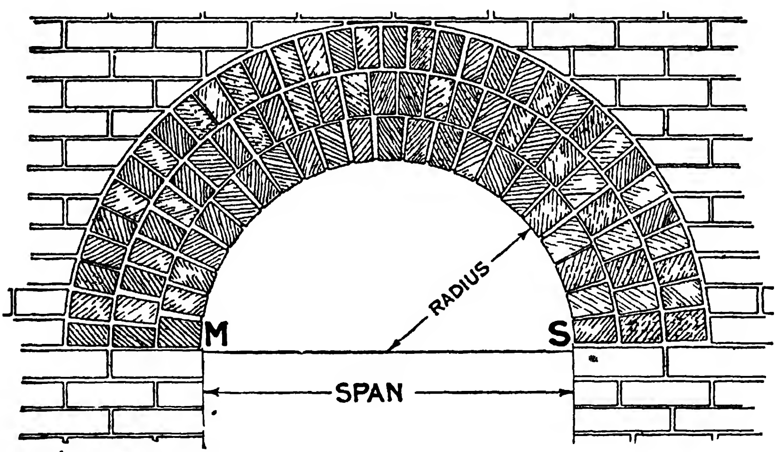


FIG. 4,318.—Semi-circular arch.

Fig. 4,320 shows a semicircular arch consisting of four rowlock courses of brick. These arch brick are all laid as headers, and show an 8 inch reveal on the under side or soffit of the arch. Arches built in this way, of a series of *rowlocks* or concentric rings, have no connection between the rings other than that afforded by the adhesion of the mortar.

Rowlock arches are frequently bonded back into the rear wall with hoop iron let in at right angles to the joints.

In order to obtain a better bond, the arch shown in fig. 4,321 is often used. This arch is bonded in several places, with stretcher brick set on end, serving the same purpose as voussoirs in stone construction. The

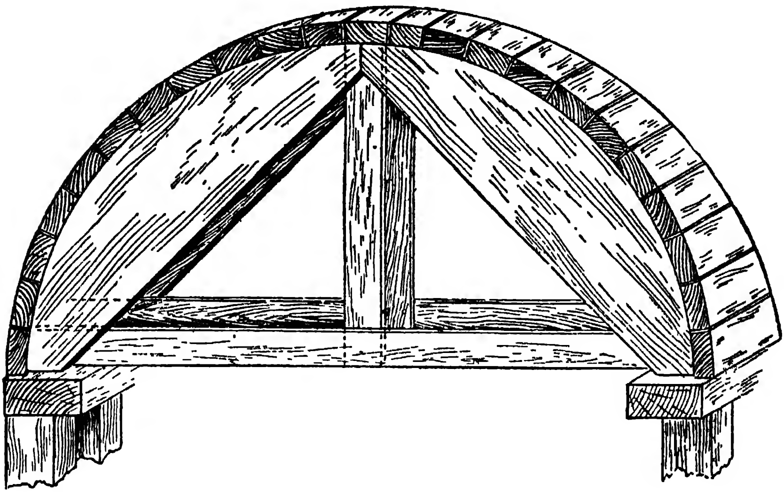


FIG. 4,319.—Form or temporary support for semi-circular arch.

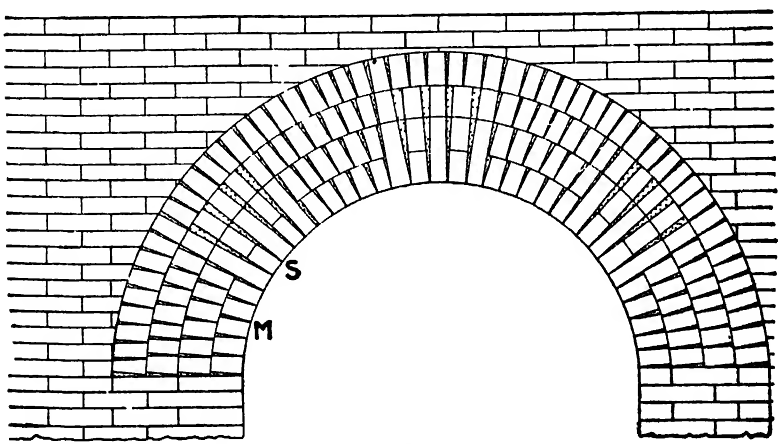


FIG. 4.320.—Semi-circular arch with four rowlock courses of standard brick.

header brick are shown at M, and the stretcher brick forming the voussoirs at S. An arch of this kind can be bonded back into the rear wall by the use of headers where the voussoir stretchers occur, and is known as a block-in-course arch.

In arches of large span built of common brick, especially in the brick lining of tunnels and vaults, the bond is often effected by building in headers, which will unite the concentric rings where the joints of two of the rings come together.

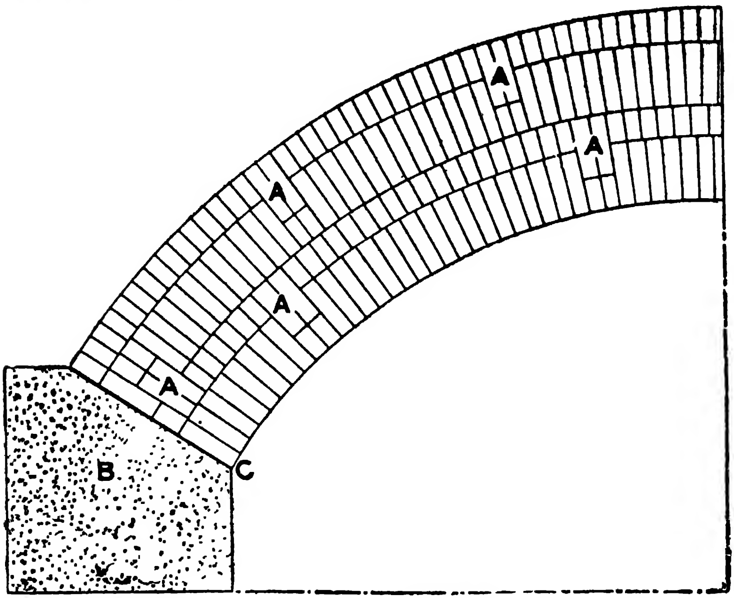


FIG. 4,321.—Semi-circular arch with four rowlock courses of standard brick illustrated stretcher transverse bonding.

An example of this is given in fig. 4,320, which shows an arch of four rowlocks, two being header and two stretcher courses, the header and stretcher courses being bonded by headers, as shown at L.

Elliptical Arches.—This type of arch gives a suggestion of a combination of both the elements of the semi-circular and the segmental arches, and when properly constructed is considered

to be a very beautiful shape, and moreover possesses great strength. Like the semi-circular arch, the elliptical arch springs from horizontal surfaces.

There is no curve that requires more care in laying out than the ellipse and various methods have been devised for doing it, most of them being more or less approximate. The most accurate and practical method for the bricklayer is by use of a

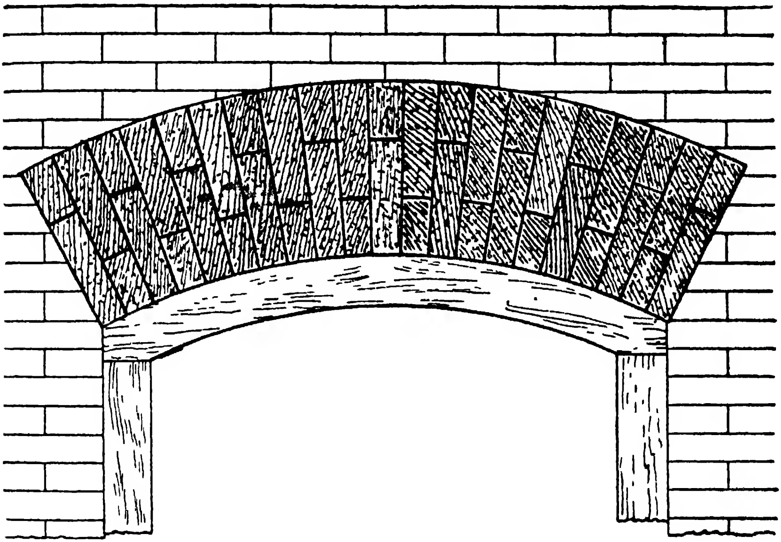


FIG. 4,322 —Segmental arch with header and stretcher courses.

trammel as shown in fig. 4,323, though the string method shown in fig. 4,324 answers very well for rough arches which have to be plastered over. It is not proposed here to give a chapter on ellipses and the reader is assumed to have some knowledge of this curve; he should at least know the difference between major and minor axes.

Pointed or Gothic Arches.—In church architecture pointed arches are extensively used. It consists of two segments turned on end and converging to a point at the top. When set out properly, this arch, unlike all other arches, has no key brick,

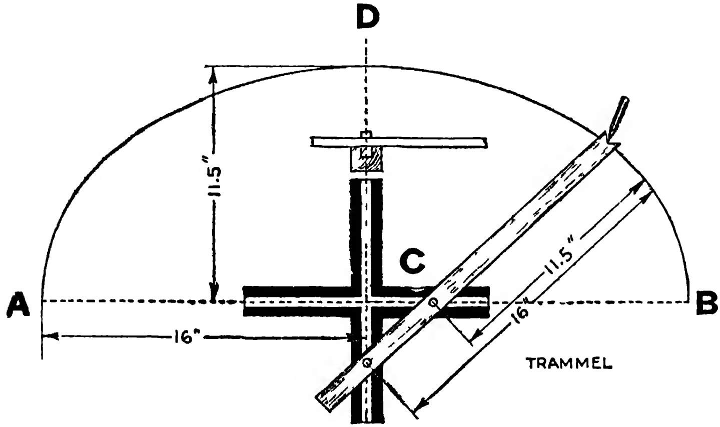


FIG. 4,323.—Method of describing ellipse with trammel. *Set out* the opening A B, upon the base line half each side of the center line CD, which will be drawn indefinitely below as well as above the base line. Prepare a square, the sides being about 2" wide and ½" thick, with a slight bevel taken off the under side of the outer edges. fix the square, the edge of one side coinciding with the centre line, but below the base line, and the other with the right hand, and answering to the half of the base line. Next take a rod (which will be known as a trammel rod) with a fixed pencil point; measuring along the rod from the pencil point, fix a screw, with the head downward, at a distance equal to the rise CD Again, measuring from the pencil point, fix a similar screw equal to the distance CB, that is, half the opening Now take some thin boarding, kept together by ledges, equal to rather more than half the opening in length, and more than the height of the rise in width, with the bottom and left end edges answering to the righthand side of the base and center lines, shot true and square to each other. Fix the mould in position with the bottom and end edge coinciding with the center and righthand half of the base lines. Then, with the trammel rod, the head of one screw working horizontally under the bevel along the top edge of the square, and the other vertically up the square, describe half the soffit upon the roughly prepared mould, which should be properly and truly cut to the curve. This may be termed the master mould Practice only will give perfection in striking this curve.

but a joint in the center, as shown in fig. 4,325. However, many object to keying with a joint and insist upon having a key brick as shown in fig. 4,326. In this case the arch has

to be set out, as all other arches, starting with half a course each side of the center line and then spacing over to the springing.

For cut work, the approximate key, which is cut as a bird's mouth is

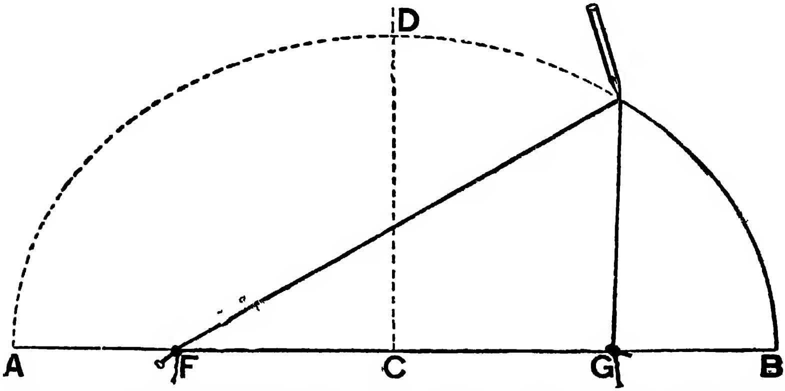
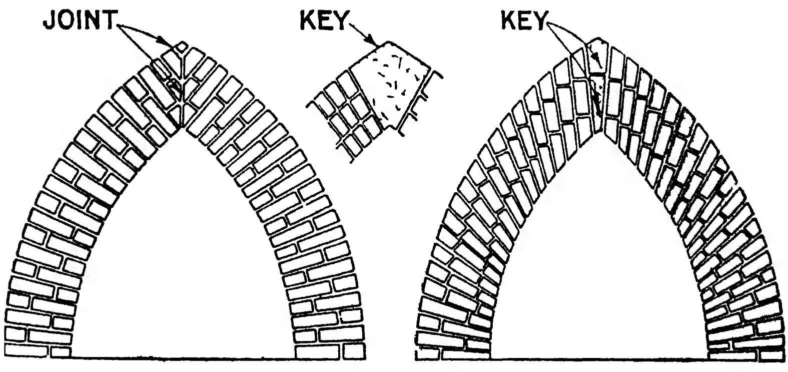


FIG 4,324 —String method of describing an ellipse. *Set out* the opening, or major axis, AB, and the center, or half-minor axis, CD. Taking the distance CA in the compasses, with the point at D, cut the base line at F and G. Then having fixed pins at F,D,G, tie the end of a piece of string or thin wire at F, pass it round D, and tie at G. Remove the pin D, insert a pencil in the loop, and, with the string or wire extended as far as it will go, describe the curve.



FIGS. 4,325 and 4,326.—Pointed or Gothic arches with joint, and with key at apex.

then filled in from the center of the base line and the approximate template obtained and traversed until it is accurate The courses are then filled in with the latter. Under these new conditions, the courses, not being normals to the curve, will all differ in length and bevel

Inverted Arches.—In foundation work to relieve some of the

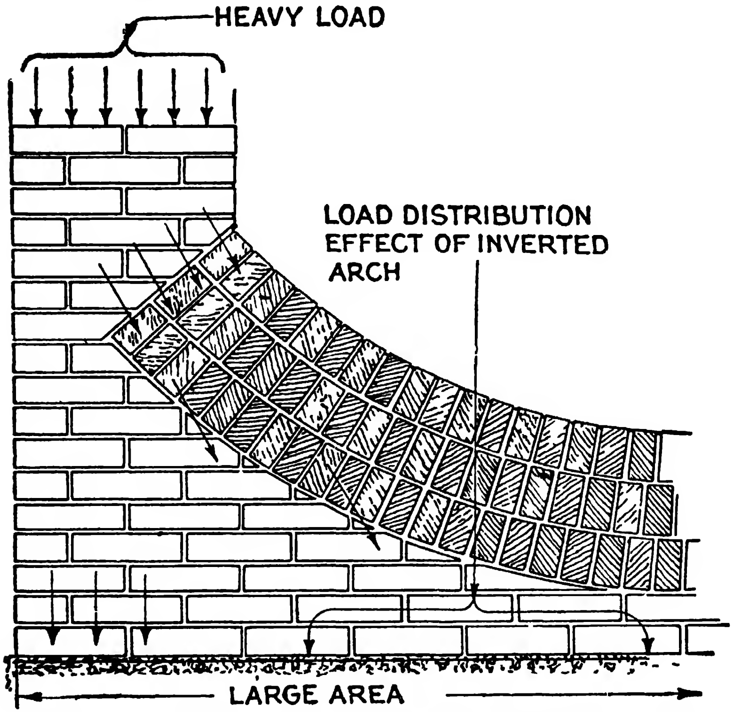


Fig. 4,327 —Inverted arch showing how it relieves or distributes the load coming on a pier

load coming on the foundation of piers the inverted arch is sometimes used. The arch is simply a segmental arch upside down, and is built into the pier as shown in Fig. 4,327. From the illustration it is clear that some of the load coming on the

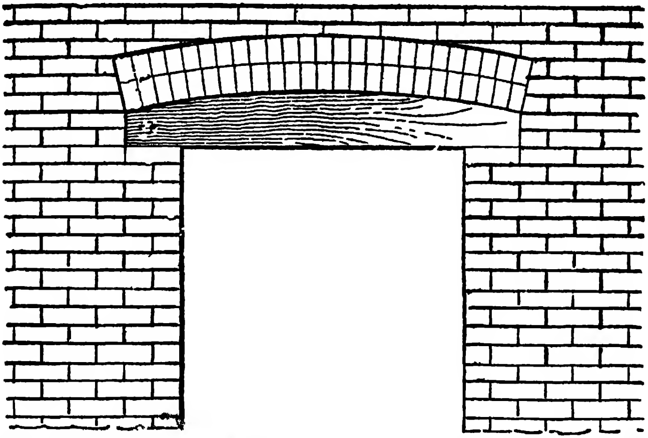


FIG 4 328 —Relieving arch with wooden lintel having its upper side cut on a segmental curve Superimposed on the lintel are two rowlock brick courses The arch is called a relieving arch because if there be any shrinking of the lintel there will be no settlement of the brickwork, the arch carrying the weight of the wall above it

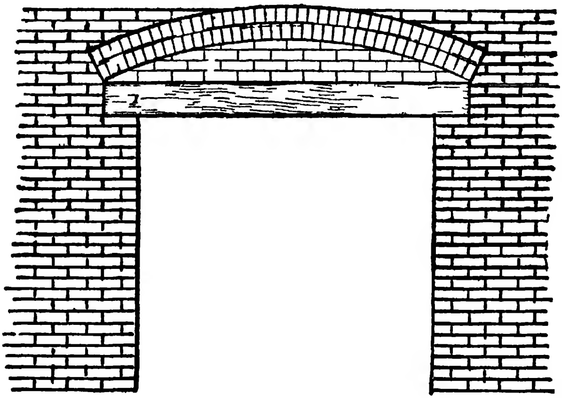


FIG 4 329 —Relieving arch with straight wooden lintel There is as shown a two rowlock arched courses with brick filler between the rowlock courses and the lintel

pier is taken by the arch and distributed laterally over a considerably augmented area.

Gauged Work.—This term relates to the rubbing and cutting of brick to any special wedge shape in arch construction. The tools and appliances required are a rubbing stone; circular in shape, a bow saw fitted with twisted annealed wire No. 18 gauge, parallel file 16 in. long, small tin scribing saw, square bevel, bedding slate to try the work for accuracy, straight edges, compass setting level, putty box, boaster, club hammer and scotch (the three latter for axed work); reducing boxes for thickness and for length moulding boxes, boxes with radial sides for obtaining the wedge shape voisson according to the template, etc. With the many special shaped brick that can be easily obtained from manufacturers, the hand cutting of brick to these special shapes must be regarded as more or less a waste of time and money and accordingly is not further explained here.

CHAPTER 75

Anchors

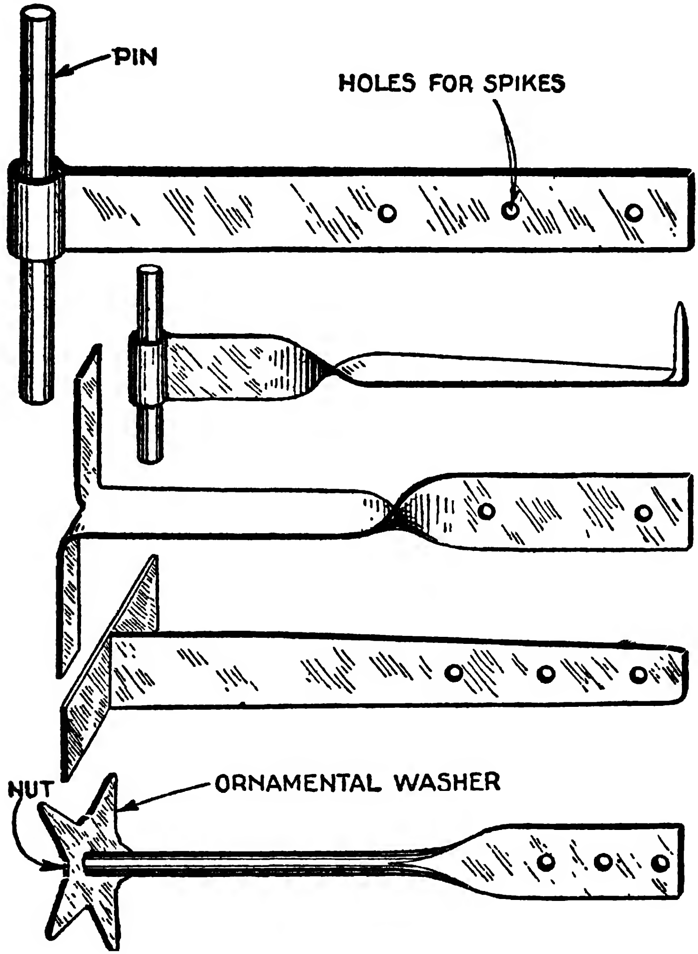
An anchor may be defined as *a strip of metal used to tie together any relative constructive members.* Thus, anchors are used:

1. To reinforce corners of brickwork.
2. To tie joists and roof plates to the brickwork.

The anchors are made in a multiplicity of shapes to meet the requirements of the service for which it is intended.

Anchoring Walls at Angles.—An important feature in brickwork is that the walls should be anchored where they meet at corners; that is, the front and rear walls should be securely anchored as well as bonded to the side, partition, or partition walls.* Figs. 4,330 to 4,334 show some forms of the rod commonly used.

*NOTE.—Distinction should be made between the various kinds of wall. *A party wall* is the separating wall between two buildings with different owners and occupants. *A fire wall* is the vertical barrier dividing two or more parts of the same property from each other. *Division walls* are walls separating buildings from each other, each being placed entirely on the property occupied by the building itself. Walls in each of these classifications should "have such stability as to remain intact after complete combustion of the contents of the building on either side of the wall and its structrual integrity shall be such as not to be dangerously impaired by the wreckage resulting from the fire or its extinguishment."—1920 discussion by *National Fire Protection Association*. It was also agreed that a fire wall "shall have such thickness as to prevent the communication of fire by heat conduction."



FIGS. 4,330 to 4,334 —Various anchors. Fig. 4,330 and 4,331 made of $\frac{1}{4} \times 1\frac{3}{4}$ strap iron about 2 ft. long attached to rod at end body flat or part round; fig. 4,332, made of $2 \times \frac{3}{16}$ iron 2 ft. long, split at end and turned up (about 4 ins) at right angles; fig. 4,333, T shape anchor of $1\frac{3}{4} \times \frac{1}{4}$ iron $2\frac{1}{2}$ ft. long, the end plate being $2 \times 4 \times \frac{1}{4}$; fig. 4,334 through anchor made by flattening out a $\frac{3}{4}$ in. bolt so as to make a $2 \times \frac{1}{4}$ flat pointers; the round end having a nut and washer as shown.

The provision for tieing consists of an anchor placed at the center of a 4 in. recess or blocking. The T or pin anchor should be built into the center of the recess which should occur every thirteen courses. The anchor should project so as to give not less than 8 ins. of holding on the wall to be tied. These anchors should never be omitted when one wall is coursed up before the wall to be tied is built.

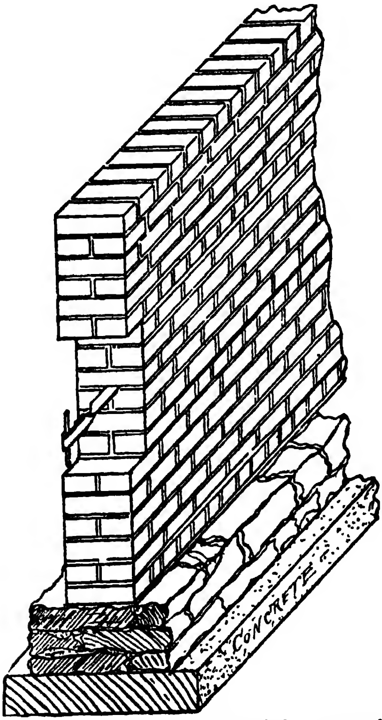


FIG. 4,335.—**Eight inch** inside wall showing anchor built into recess for tying corner or intersecting wall.

Anchoring Floor Joists.—In brickwork the courses can easily be adjusted, so that the courses supporting joists will be at the exact height required. No "shims" or blocking under the joists are needed or should be allowed.

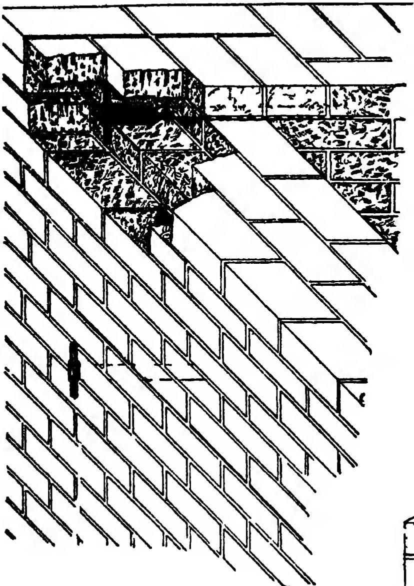


FIG 4,336.—End of 8 in inside wall showing method of building anchor into the wall

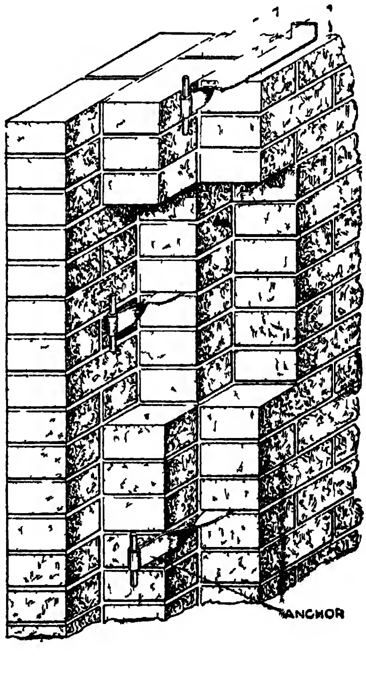


FIG 4,337.—End of 12 in side wall showing anchors built in and ' teeth ' for tying front wall

Joists and timbers should be set directly on the brick, unless their bearing surface is so small that they transmit a load over the safe bearing capacity of the wall, which occurs very seldom, but which would require bearing plates.

These two conditions are shown in figs. 4,339 and 4,340.

In the better class of residence work floor joists are anchored to the walls. Some cities require this by ordinance. In the

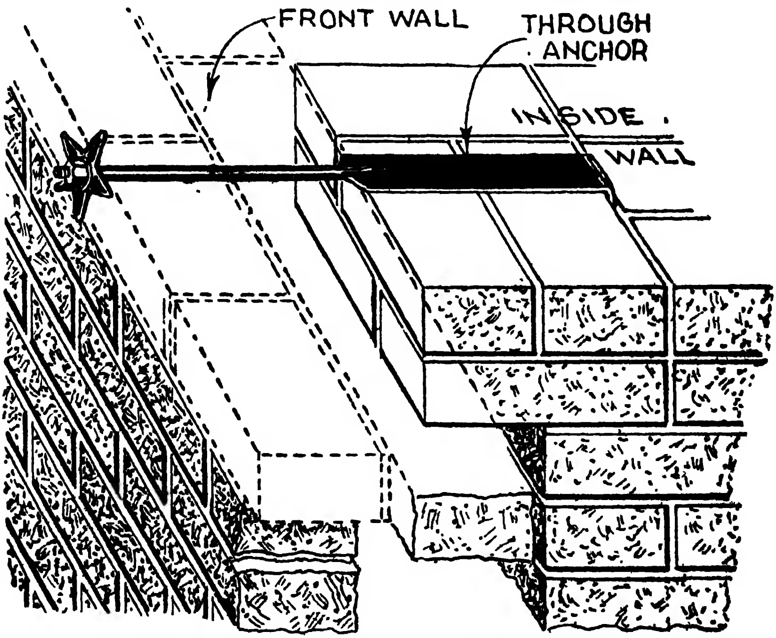
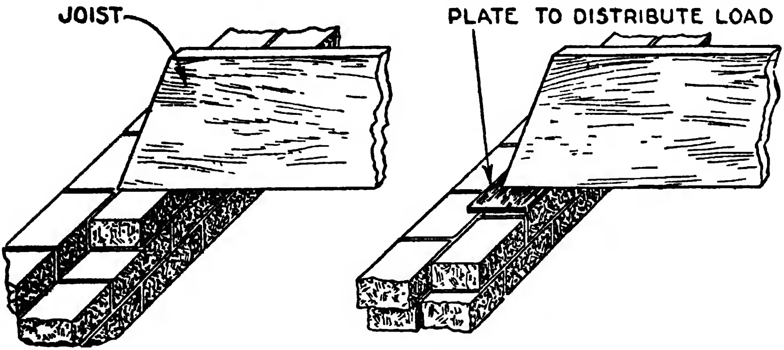
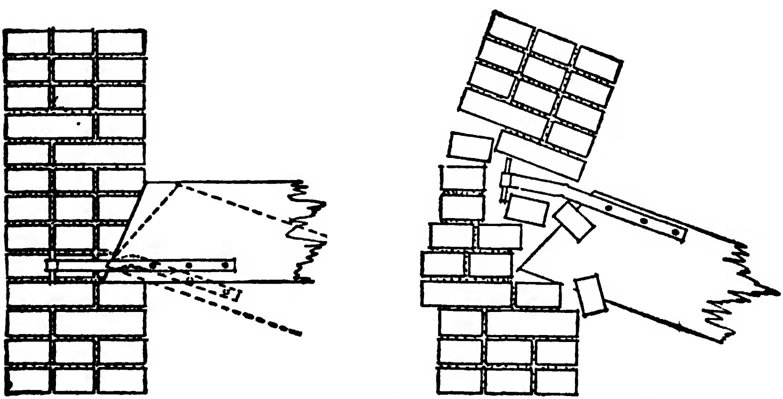


FIG. 4,338.—**Intersection of front and inside wall showing placement of through anchor.**

great majority of cheap residence work outside of such cities, however, anchors are not used. Anchors are spaced approximately six feet apart both for floor joists and roof plate. Great care should be exercised in placing these anchors as near the



FIGS. 4,339 and 4,340.—Placement of joist on brick wall showing ordinary construction and metal plate bedding to distribute a heavy load.

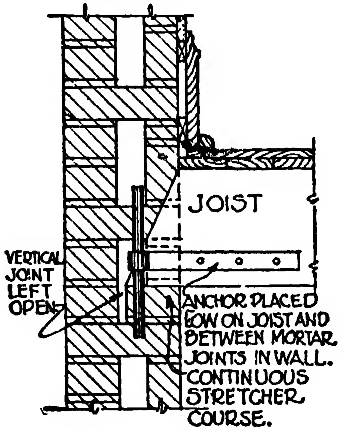


FIGS. 4,341 and 4,342.—Right and wrong placement of joist anchor. In fig. 4,341 the dotted position of joist shows its collapse, bending anchor without rupturing wall. The result of placing anchor at top of joist is shown in fig. 4,342.

bottom of the joists as possible, in order to lessen the strain on the brick wall, in case a fire cause the joists to drop.

Figs. 4,341 and 4,342 show right and wrong placement of joist anchors in solid walls, and figs. 4,343 and 4,344 the correct placement in hollow walls.

In constructing the walls the brickwork should be stopped at the point where the first floor joists are to rest upon it, and care should be taken to have the top course perfectly level, so that the joists may be set without



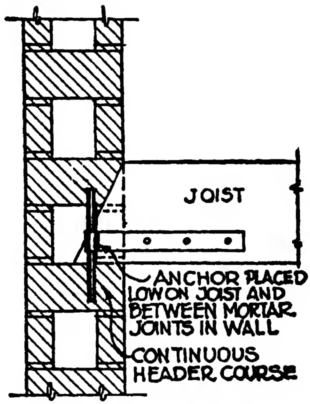


FIG. 4,343.—Concealed joist support forming fire stop in 8 in. hollow Ideal wall.
FIG. 4,344.—Placement of joist anchor in 8 in. hollow, all rolok wall.

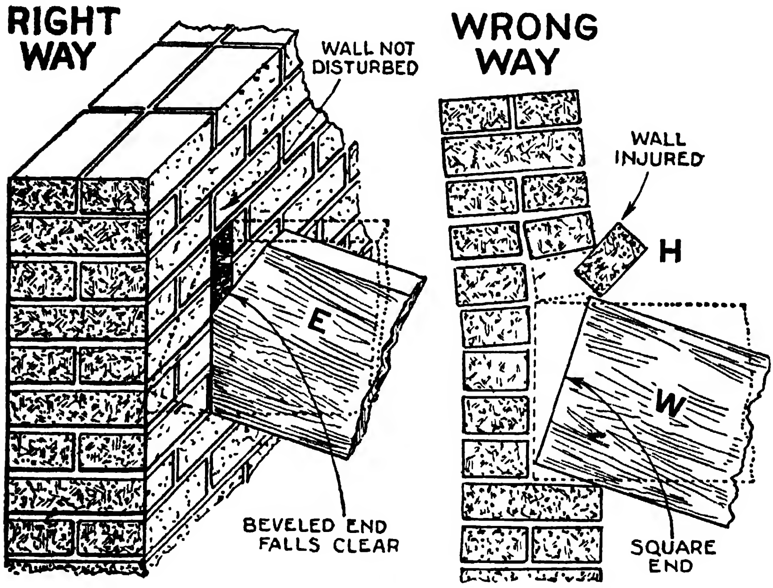
wedging or blocking. After the joists are placed, the brickwork is continued up between, and leaving a small "breathing" space around them to prevent dry rot. The same method of joisting is followed at the upper floors.

On anchor joists the anchors are attached to the joists with spikes driven through the holes seen in the illustrations of anchors.

The ends of all the joists are beveled whether they be anchor joists or intermediate joists so that in case of fire they will readily fall without injury to the wall as shown in fig. 4,345.

The appearance of joists as built into the wall is shown in fig. 4,347. Where joists run parallel to the wall, the anchor straps are made long enough to be attached to about three joists, into which they are mortised on top as shown in fig. 4,348.

Fire Stops.—If the lower part of a wall be thicker by a brick than the upper part, it should be carried up its full thickness



Figs. 4,345 and 4,346.—Why the ends of joists are beveled. Evidently in fig. 4,345, if the joist **E**, collapse it will leave the wall as it falls without disturbing the brickwork, whereas with square end as joist **W**, fig. 4,346, it would act as a lever and pry over the top **H**, injuring the wall.

nearly to the top of the joists where it is stepped back to the inside face of the upper part, thus forming with the plastering a fire stop at the top of the joists, while a projection of a quarter brick length should always be provided as a fire stop at the bottom of the joists as shown in fig. 4,349. If the wall be the same thickness throughout, the brickwork should be corbeled

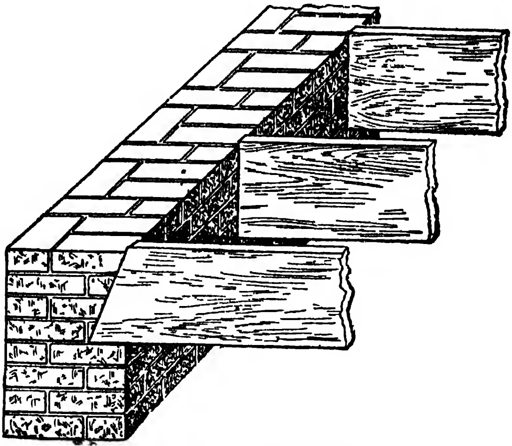


FIG. 4,347.—Appearance of joists built into the brick work.

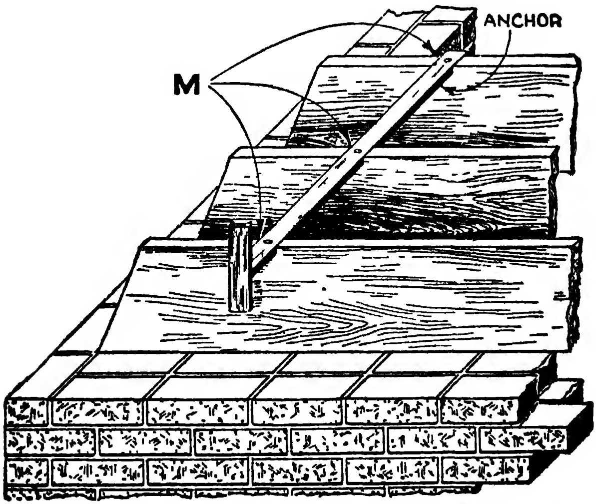
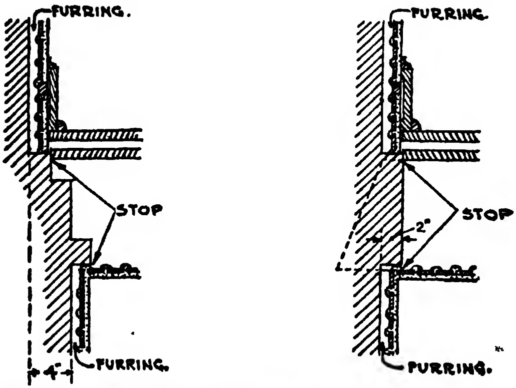


FIG. 4,348.—Method of anchoring joists to the walls where the joists are parallel to the walls. The anchor is let into the joists as shown at M, and it should be long enough to run over two or three joists in order to give proper stiffness. The T form of anchor here shown is best for this purpose.

out between the joists two inches, the full height of the joists to form a fire stop as in fig. 4,350.

The object of the fire stop is to block all possible passage of fire from the space between the joists to that between the furring strips on the wall, or the reverse. Without these fire stops, a fire originating in the floor could communicate with the furring space on the wall above, or originating in the furring space could communicate with the floor. With the stops, the



FIGS. 4,349 and 4,350.—True corbeling between joists.

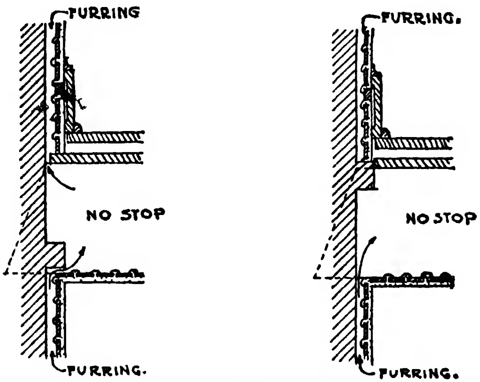
fire is confined to certain spaces and is retarded instead of spreading. These corbels also serve the wholesome purpose of checking vermin of all kinds from passage through the floor and wall spaces.

Figs. 4,349 and 4,350 also show the proper way of placing the lath at the corner of the ceiling so as to take full advantage of the fire stops. The ceiling lath, usually placed first, should be started far enough away from the side walls so that when the side wall lath is placed tight, as it ought to be, against the underside of the floor joist, there will be space enough for the plaster to push through and form a key touching the bottom brick of the corbel. As the corbel by construction is necessarily the distance of a

mortar joint above the bottom of the joists, the openings are thus completely sealed by the plaster key. In cheap speculative buildings, these fire stops are too often omitted or a pretext for them is resorted to by projecting only one brick at the top or bottom of the joists. This however, is as good as no fire stop at all.

Figs. 4,351 and 4,352 show wrong way of placing the lath and also how false corbeling leaves the passages really unstopped, this defeating altotogether the purpose of fire stops.

Masonry walls that are to be furred, sometimes have, as the work progresses, common wood laths laid in the joints of the brickwork on the inside face of the wall, about every seventh course, except over chimneys.



Figs. 4,351 and 4,352.—False corbeling between joists.

The lath should be staggered so as to avoid two vertical lath joints in succession. These serve as nail holds for the furring strips.

Anchoring the Roof Plate—Before the top of the wall is reached, the anchors for bolting down the roof plate should be placed and the brickwork carried up around as shown in fig. 4,353. They should be made of half-inch bolts at least 12 inches long, with a tee or washer at the bottom and a nut and washer at the top, and should be set approximately every 6 feet along the wall. After the carpenter has placed the roof

plate and before it is bolted down, the mason should bed with cement mortar under it.

When the wall is finally carried to the top and the roof rafters set, but before the roof boarding is in place, the mason should fill in between the roof rafters with one tier of brick as shown

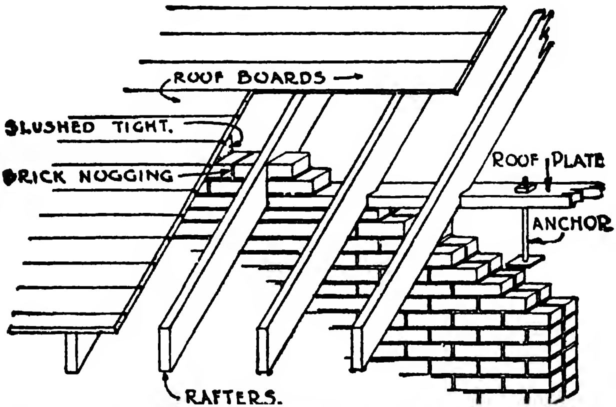


FIG. 4,353.—Method of anchoring roof plate showing rafters and roof boards in place.

in fig. 4,353. This is called nogging. Its purpose is to block effectually the openings between the roof rafters and prevent the wind entering the walls and attic. This adds greatly to the comfort of the house in cold weather. In warm climates, nogging will be found unnecessary.

CHAPTER 76

Foundations

The subject of foundations as here treated includes the supporting walls below the ground level, and the piers which carry the girders.

Naturally, the excavation should be carried down to good solid earth, free from loose, spongy soil or filled-in ground which might later permit sufficient unequal settlement to result in serious cracks throughout the wall of the house.

Footings.—This is the lowest part of the foundations and is that part which transmits the weight of the building and loads coming on it to the ground at the bottom of the excavation. The object of the footing is to distribute this weight over a large area so that the pressure per sq. ft. coming on the ground or *foundation bed* will be small and thus prevent settling of the ground.

Where the soil is uniform the pressure per sq. ft. transmitted by the footing should be the same and in no case should this pressure exceed the amount allowed for the kind of soil encountered where the excavation is made. These allowances or safe loads are given in the following table:

Safe Loads on Foundation Beds

Kind of foundation bed	Safe load in Tons per sq. ft.
Rock	15 to 30
Sand, gravel and boulders	5
Fine sand	2
Hard pan	10
Clay { ordinary	2
Clay { large % sand	4

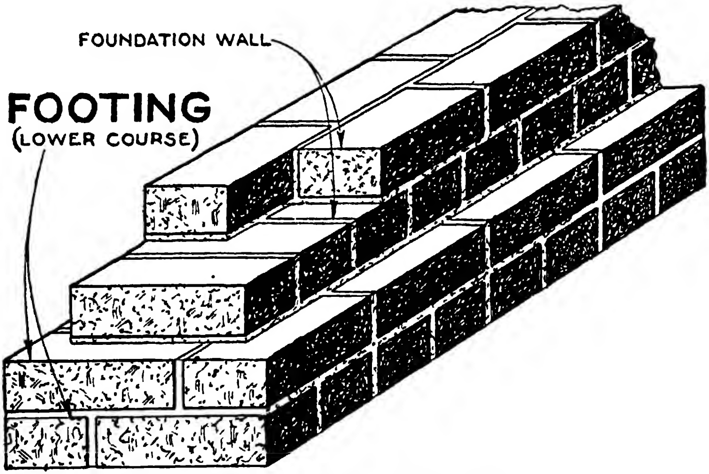


Fig 4,354.—12 in. brick footing supporting 8 in. foundation wall.

Example.—The weight to be transmitted by the footings of a small 10×20 garage is 500 lbs. per sq. ft. of floor area. What size footings should be provided if the foundation bed be of fine sand?

$$\text{Floor area} = 10 \times 20 = 200 \text{ sq. ft.}$$

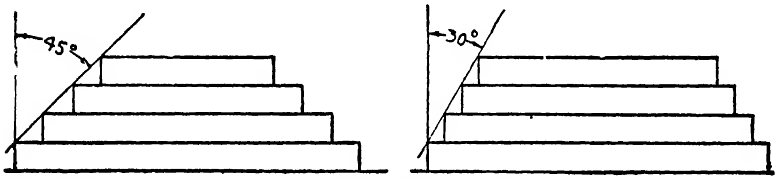
total weight to be carried $= 200 \times 500 = 100{,}000$ lbs.,
or $100{,}000 \div 2.000 = 50$ tons.

From the table the safe load for fine sand is 2 tons per sq. ft., hence

Area of footing $=50\div2=25$ sq. ft.
Approximate length of footing $=(2\times10)+2\times20=60$ ft.
Width of footing $=(25\div60)\times12=5$ ins.

In a case like this the footing would be made not less than the thickness of the wall or 8 ins.

Footings are usually made of concrete but they may be of brick laid in good cement mortar as shown in fig. 4,354. The footings should be strengthened at points of special bearing stress. Which footing is chosen will depend largely on convenience of getting local material and labor. The bottom of



FIGS. 4,355 and 4,356.—Brick footings with 45° and 60° stepping.

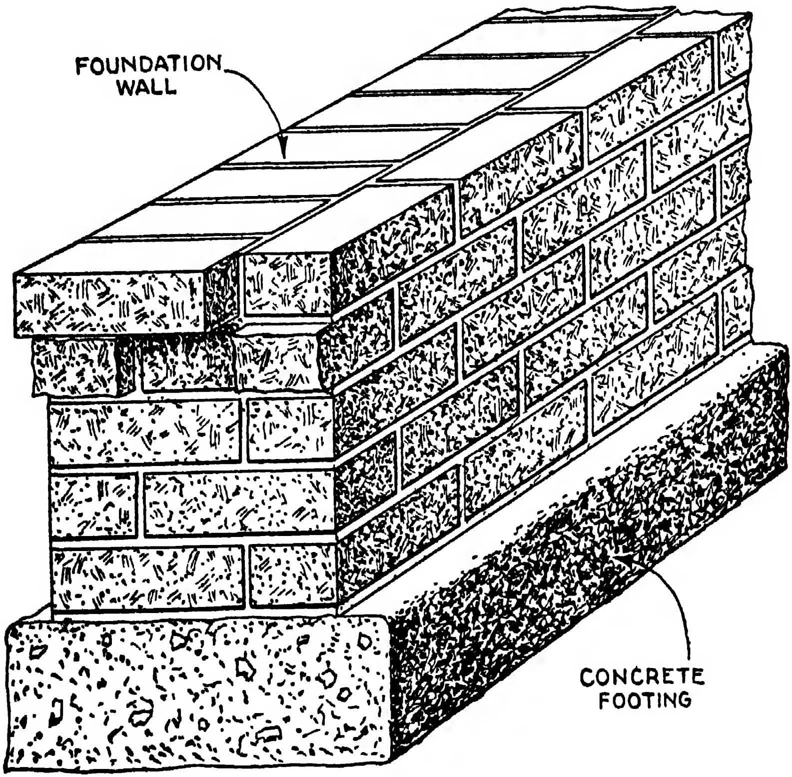
the foundation wall or footing must always be below frost line, which of course varies in different sections of the country; and this rule applies as well to all brickwork outside of the foundation wall proper.

Where conditions of soil require, porous tile with open joints should be laid around the base of the foundation wall, not above the level of the basement floor nor below the bottom of the wall or footing, and slightly pitched to a point where it may be connected with the sewer or some natural outlet. Where this tile is laid in loose sand soil, the open joints should be wrapped with building paper to prevent the sand from clogging the drain. In heavy clay soil, the tile should be covered to the depth of about a foot with crushed stone to prevent packing of clay around the tile.

In brick footings the bricks are laid so that the steps are at 45° or 60°. The 45° stepping is easily obtained by setting back two ins. on the square

of the thickness of each brick, until the thickness of the wall is reached. For 60°, one in. stepping is made on each course.

Foundation Walls.—By definition, foundation walls are those walls below the grade line of the building that support the super-structure. Similar walls around areas are termed



brick foundation wall of 12 inches, for two-story buildings, or one of 8 inches, for small one-story buildings, conforms to good practice.

The foundation wall should be built of a hard burned common brick, and laid in common bond as shown in fig. 4,357.

With a good cement lime mortar, starting at the bottom with a header course. As the headers, which serve as transverse bond, are not long enough to extend through the entire thickness of the 12 inch, as they do through the 8 inch wall, the header courses in the 12 inch wall very naturally cannot be on the same level at the front and back of the wall. In the bottom course the header row is laid inside and the stretcher row outside, while in the next course above the position is reversed, and so on wherever the bonding header courses come.

The first course of brick is well bedded in mortar on the footing or the solid ground, as the case may be. At the corners and at proper intervals along the wall where necessary, a few brick, four or five courses high, are laid up in advance to serve as leads or starting points for the bond and supports for the line which guides the mason to the proper level and alignment of the brick. The mortar is well spread with the trowel along the top of the brick course, and the brick to be laid is firmly pressed down on this mortar bed next the lead. The mortar thus squeezed out of the joint is cut off by the trowel and scraped on the head of the next brick to be laid which is then pressed on the mortar bed and shoved against the brick just laid, so as to squeeze mortar into the bottom of the vertical or head joint which is then thoroughly filled from the top by slushing with mortar. The stretcher courses for structural reasons should be well slushed with mortar between the front and back rows or tiers of brick, said to break joint.

As the work progresses, the joints on the inside face of the basement wall should be neatly struck, while the outside joints should be cut flush for receiving a waterproof coating. The inside joints are struck by running the point of the trowel, held firmly, at an angle, along the upper or lower edge of the brick, thus making a smooth beveled joint.

The wall should be widened where indicated on any plan to serve as a foundation for the fireplace, and should be built hollow to provide for an ash pit. Where other chimneys occur, the wall at their base should be corbeled out to serve as a support for them.

After the wall has risen four or five feet, scaffolding is erected to carry on the upper portion. The scaffolding, necessary for the usual house, or other small building, consists of a series of rigid horses, on which are placed a half-dozen 2″×10″ planks laid close. The joists for the floor above may be used for this planking and then lifted into place when the wall is ready to receive them, thus effecting a saving in labor. Care should be taken to keep the horses several inches away from the inside face of the wall, lest the jarring caused by bricks and mortar being deposited on the scaffold may push the green wall out of plumb. The scaffolding for the foundation wall may be dispensed with, if it be found more convenient to lay the upper portion of the wall from the outside.

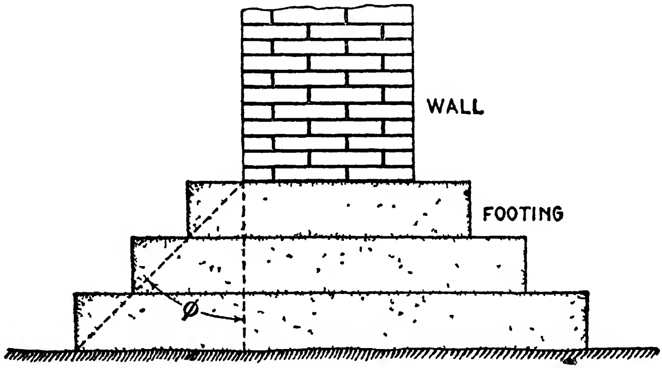


FIG. 4,358.—Angle for foundation footing. *In ordinary practice* the footing courses upon which the walls of the building proper rest, consist of blocks or slabs of stone as large as are available and convenient to handle Footings of brick or concrete are also used in very soft soils; footing consisting of timber grillage are often employed A grillage of iron or steel beams has also been used successfully The inclination of the angle of footing should be about as follows for metal footings, 75°, for stone, 60°, for concrete, 45°, for brick, 30°. Damp proof courses of slate, or layer of asphalt are laid in or on the foundations or lower walls to prevent moisture arising or penetrating by capillary attraction

NOTE.—All brick foundation walls should be water proofed on the outside except in gravelly, sandy or very dry soil In case there be danger of moisture rising in the wall, by capillary attraction, the top of the footing should be waterproofed before starting the walls, by a course of slate well bedded in mortar or by a strip of composition roofing In wet locations, it would be well to carry the waterproofing under the basement floor also.

NOTE —*In waterproofing foundation walls,* in slightly wet soils where the drainage is fair, a coating of one half inch cement plaster may be applied to the outside surface of the brick as the wall is carried up This plaster should be composed of one part Portland cement and two parts clean, sharp sand The possibility of settlement cracking this cement coating makes it undesirable for use in heavy soils such as wet clay, or in low lying land where the sub-soil is likely to be wet In such conditions, a coating of asphalt applied while boiling hot, thoroughly covering the brickwork, is very satisfactory

In very exposed locations subject to high winds and the building is to be of wood construction, the sills should not be simply laid on the foundations as is usual but should be properly anchored as shown in fig. 4,359.

Piers.—As here considered, a pier is a detached part of the

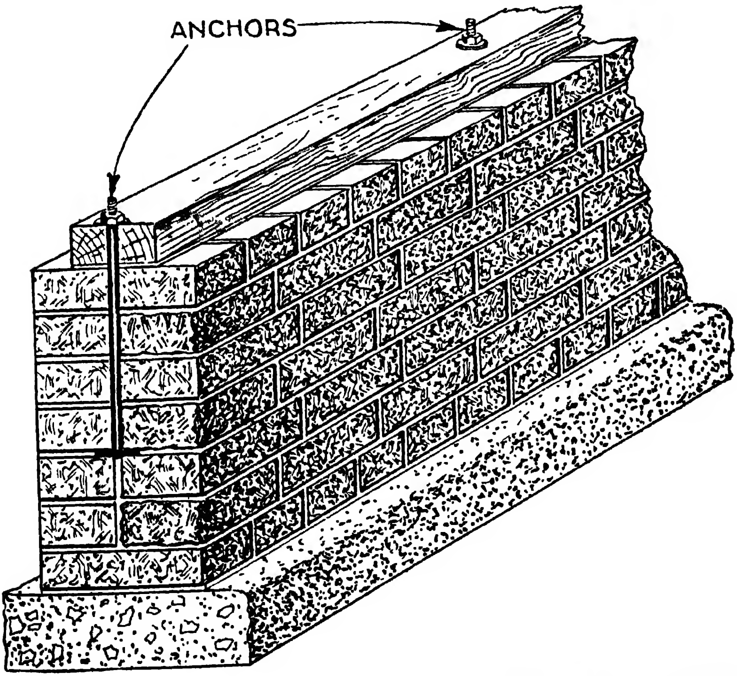


FIG. 4,359.—Plate anchors built into brick foundation walls for anchoring sills of framed building.

foundation consisting of a column of brickwork usually of rectangular cross section and serving to support the girders. Piers may be classed:

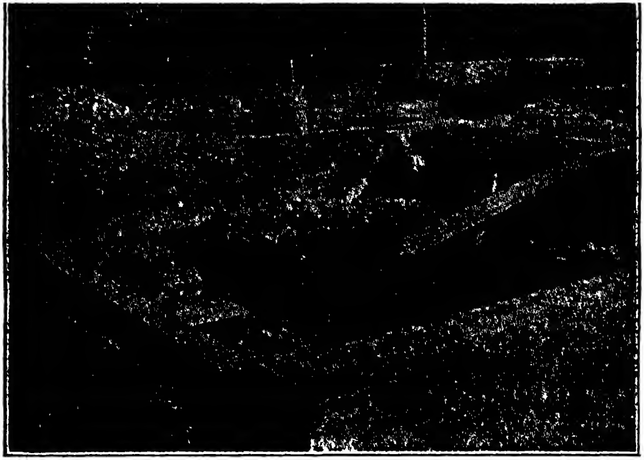


FIG. 4,360.—Brick foundation during construction. Note the small amount of equipment needed and the simplicity of building a brick basement.

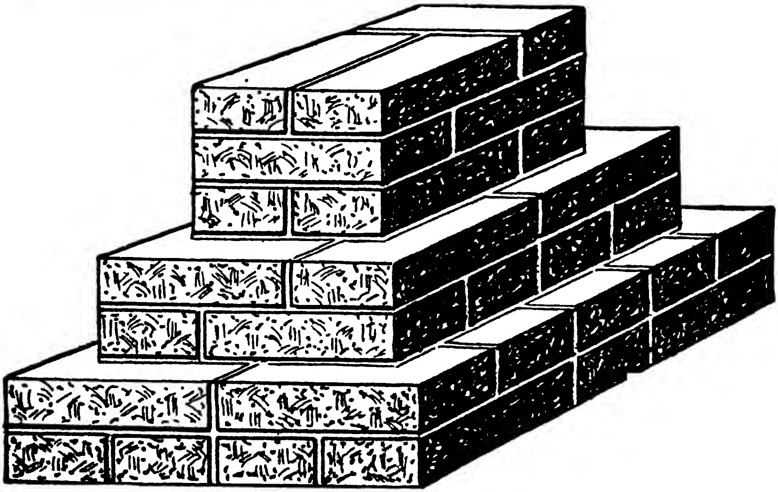


FIG. 4,361 —Footing for 8 × 12 solid pier showing bond.

1. With respect to construction, as

   a. Solid
   b. Hollow

2. With respect to location, as

   a. Isolated.
   b Connected.

3. With respect to shape, as

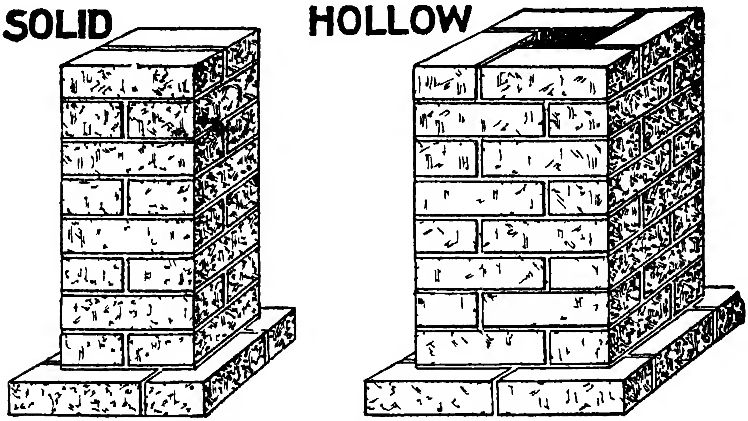


FIG 4,362 and 4 363 —8×8 ***solid*** pier and 12×12 ***hollow*** pier

   a Straight.
   b. Battered.

A typical stepped brick footing for an 8×12 solid pier is shown in fig. 4,361. The construction of building an 8×8 pier is very simple as the brick are laid alternately header and stretcher on each course, two brick to a course as shown in fig. 4,362.

The hollow type of pier is shown in fig. 4,363.

As shown, the brick are placed so as to show headers and stretchers on all four sides. A stronger job may be obtained by inserting a course of headers in every sixth course, as in a straight wall thus crossing the bonds

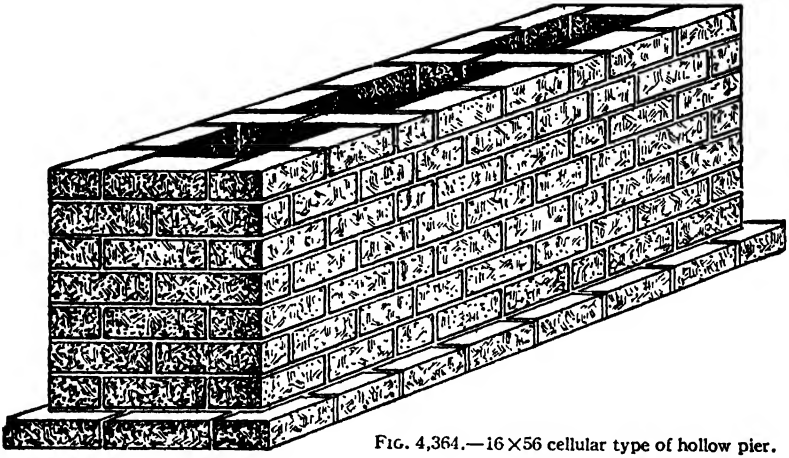


FIG. 4,364.—16×56 cellular type of hollow pier.

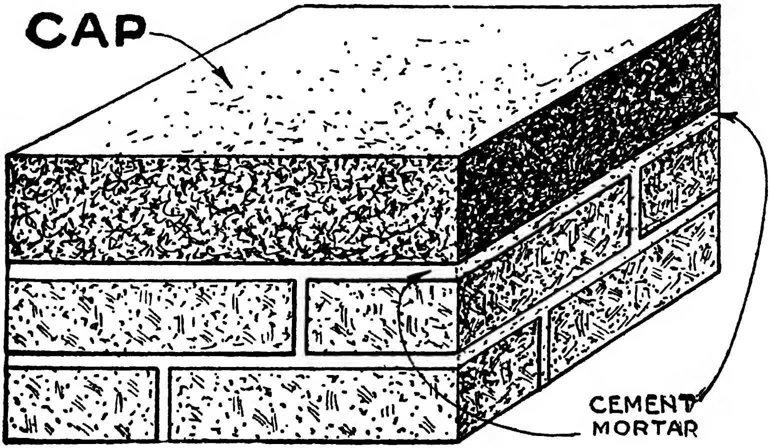


FIG. 4 365 —Stone cap for 12×12 pier showing it bedded with cement mortar. Too much care cannot be given to making this joint perfect because on this depends the equal distribution of the load

The hollow principle may be applied to larger piers giving a cellular construction as shown in fig. 4,364.

Piers should have a cap at the top so that the load coming on them for the girders will be equally distributed; this is especially necessary with hollow piers.

The cap may be a stone or an iron casting and in either case it should be thoroughly bedded in Portland cement mortar, as shown in fig. 4,365.

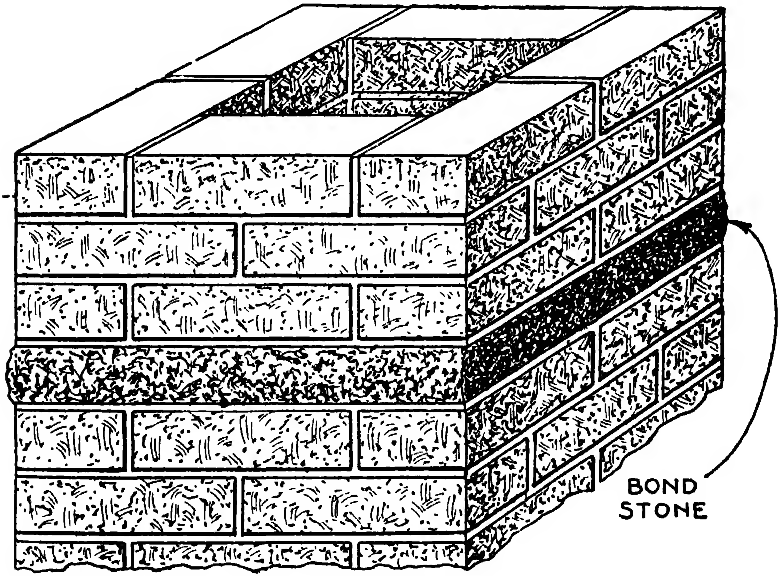


FIG. 4,366.—Bond stone placed at intermediate points in pier to reinforce by thoroughly bonding the mass of brickwork.

In order to strengthen piers *bond stones* are inserted at proper intervals as shown in fig. 4,366.

These bond stones give greater coherency to the pier by connecting its

NOTE.—No pier over 8 ft. high should be less than 12×12 in. in cross section and when from 6 to 8 ft. high, piers should be at least 8×12 in. in cross section.

constituent parts or bricks together but they might be safely omitted in 8 in. isolated piers, as there are scarcely sufficient brick in width to require them unless the pier be unusually high.

In regard to the height of piers, that is, the ratio of height to minimum transverse dimension, *no isolated pier should exceed in height 10 **times** its least transverse dimension.*

The opinion prevails that the tying in of masonry with header courses helps to strengthen piers against bulging action, thereby increasing the strength in proportion to the number of headers used. Results obtained in recent tests of brick piers, however, show that variations in the number of header courses used do not have a positive effect on the compressive strength of the pier. The ordinary proportions of bond stones are from 5 to 8 ins. in thickness and the full size of the pier in cross section spaced every 3 or 4 ft. in height.

CHAPTER 77

Boiler Settings

Because of the very extensive use of the horizontal return tubular boiler and other types requiring elaborate brick "settings," all bricklayers, especially those in rural and remote districts, should understand how to build a brick setting.

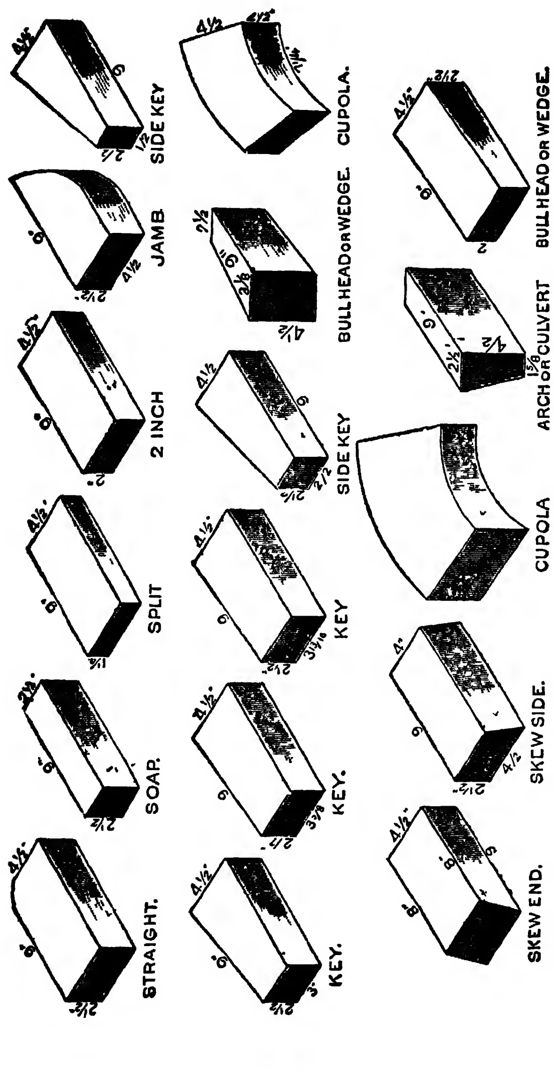
Although this work is generally done by specialists, when available, the ordinary bricklayer is frequently called upon to brick up a boiler. He should therefore thoroughly understand the requirements because if the work be improperly done, the setting will always be a source of trouble.

The quality of the brickwork in which steam boilers are set will vary the quantity of fuel used by as much as one-fifth; hence the importance of knowing the correct principles upon which the work should be done.

Kinds of Brick Used.—Two kinds of brick are used in boiler setting—the *common* brick for walls, foundations and backing to the furnace, and so-called *fire brick*. The latter are made in a multiplicity of special shapes to fit the curves of the furnace.

The usual forms of these brick are shown in figs. 4,367 to 4,383.

The quality in fire brick which renders them useful is their power to resist for a long time the highest temperatures and sudden changes of temperature without injury, and their ability to resist the action of the hot gases.



Figs 4,367 to 4,383 —Names for standard shaped fire brick as adopted by the *National Fire Brick Manufacturers' Association.* As made by Henry Maurer, the best quality is branded "No 1," a cheaper quality is made without any brand. Another brand called "Bauxite," is made for use where acids come in contact with the brick and where the most intense heat is generated; these brick are claimed to be more durable than the best fire brick, to resist the most intense heat, as also the action of basic slags. After heating for some time they become very hard which helps to resist mechanical action of wear and abrasion

Requirements of a Boiler Setting.—The setting as well as construction of boilers differs greatly, but in all the end to be sought for is:

1. High furnace heat.
2. Minimum heat waste.

To attain these conditions there must be:

1. Sufficient thickness of wall around the furnace including a bridge to retain as nearly as may be the heat generated.
2. Proper mixture of air.
3. Proper area of grate.
4. Adequate combustion space.

Principal Parts of a Furnace.—The bricklayer should be familiar with the names and functions of these parts. They are as follows:

The furnace proper or fire box, being the chamber in which the solid constituents of the fuel and the whole or part of its gaseous constituents are consumed.

The grate, which is composed of alternate bars and spaces, to support the fuel and admit the air.

The dead plate, that part of the bottom of the furnace which consists of an iron plate simply

The mouth piece, through which the fuel is introduced and often some air.

The lower side of the mouthpiece is the deadplate.

The fire door. Sometimes the duty of the fire door is performed by a heap of fuel closing up the mouth of the furnace.

The furnace front is above and on either side of the fire door.

The ash pit. As a general rule the ash pit is level, or nearly so, with the floor on which the fireman stands, and as for convenient firing, the grate should not be higher than 28 to 30 inches, the depth of ash pit is thereby determined.

The ash pit door is used to regulate the admission of air.

The bridge wall.

The combustion or flame chamber.

Horizontal Return Tubular Boiler Settings.—This type of boiler requires an elaborate setting, as the latter forms the furnace and combustion chambers, and with lug supports, carries the weight of the boiler. The setting consists of:

1. Foundation.
2. Enclosing walls.
3. Bridge wall.
4. Combustion chamber.
5. Top covering.
6. Arch.
7. Trimmings.

Foundation.—In selecting the location of a boiler it is important to consider the nature of the soil upon which it is to rest, because unless a firm foundation be provided, trouble is quite sure to result in the way of cracked setting walls and leaky steam pipe joints caused by sprung piping when the foundation settles.

The required size and shape of the foundation will depend on the bearing power of the soil, the weight of the setting plus the weight of the boiler when full of water and fitted with such accessories as rest on the foundation. With a boiler resting directly on the side walls of the setting the side wall footings may be assumed to bear the entire weight of the boiler as a uniformly distributed load. Except where the soil is poor it will not be necessary to make the width of the footings more than 8 inches greater than the thickness of the setting walls.

The depth to which the foundations should go also depends upon the nature of the soil. Trenches may be dug to a depth of three or four feet, and footings placed within them.

Large *stones or concrete* are to be recommended for the footings of the

walls and bridges, the earth being well rammed into the trench as soon as the walls have risen above the ground level.

If the ground be soft, the whole area should be excavated to three feet depth, and the pit filled with two feet of sand or gravel well rammed, or still better, with concrete. On marshy ground, wooden platforms or grillage may have to be used, in connection with short driven piles, all woodwork being entirely submerged to prevent its decay. *Heavier foundations should be used for boilers than for ordinary buildings*, as the least settlement may be dangerous, setting up strains caused by weight.

In proportioning the footings calculate the total weight coming upon the footings which comprise: weight of masonry, boiler, water and fittings, then *make the footings large enough so that the pressure on the soil will not exceed* ***two tons** per **sq. ft.***

Foundation Material.—Concrete is the material now used almost universally for foundations. The best concrete is made with broken stone or gravel with a cement sand mortar for the binder.

The usual proportions for foundation work are as follows: one part cement, two and one-half parts sand and five parts broken stone or gravel, whichever be more available or cheaper to obtain. A good standard brand of cement should be used.

Blocking the Boiler.—After completing the foundation, the next step is to put the boiler in place. It is first raised by jack screws or levers to the height at which it is to set, and blocked there by cribbing made of short pieces of timber as shown in fig. 4,384.

Enclosing Walls.—The difference in first cost between a good

NOTE.—***Laying Out the Foundations.***—As a general rule the boiler manufacturer supplies a drawing showing the design and dimensions of the setting. From this and from the character of the soil the foundations may be laid out. If no drawing be furnished, the design may be taken from the accompanying designs and dimension tables, which represents standard practice.

job and a poor job is comparatively slight and once paid for there is an end to it.

Poor construction means cracks and air leaks, the worst enemies to efficient boiler performance, causing useless waste of fuel.

The exterior of the walls should be hard burned brick, and the lining of furnace and combustion chamber, fire brick.

Every sixth course, beginning with the grates, should be a row of ***headers***,

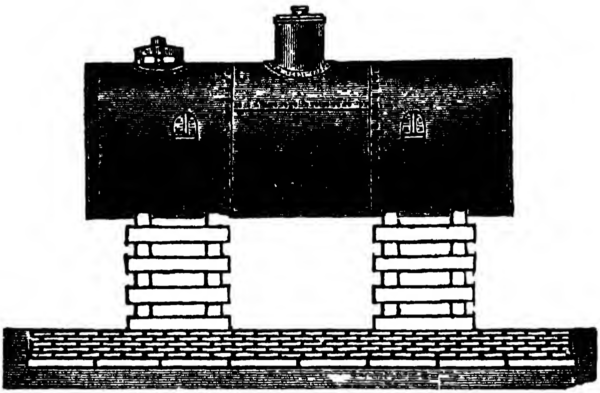


FIG. 4,384.—Boiler blocked up ready for setting. When the boiler is to rest on the setting walls it should be blocked up about an inch higher than its final position so that the side walls may be finished without difficulty after which the boiler may be lowered into position. The boiler front should not be required to carry any of the weight of the boiler, hence there should be about ½ inch clearance between the bottom of the shell and the front. The boiler should be inclined toward the rear so as to cause it to drain through the blow off easily and to give a little extra depth of water over the rear end of the tubes. If the front end of the boiler be set about 1 inch higher than the back, the desired slope will be obtained. ***In leveling*** the boiler crosswise, the top row of tubes should be taken to gauge by and not the faces of the steam nozzle flanges. If the nozzle flanges be but slightly out of true with the tubes the difference can probably be made up in the packing of the joint. If they be considerably out of true special flanges may be used in making up the joints. It is preferable to have the tubes level rather than the flanges. The reason for this is that with unlevel tubes it is necessary to carry a higher water line than ordinary in order not to expose the high tubes and this is unsatisfactory as it cuts down the steam space.

well bonded into the masonry behind; the headers being of little use unless they are so bonded, for when the lower courses of fire brick have been burned away, it is necessary to rely on the headers to a great extent to hold the upper part of the wall in position, and if they have been laid with due care the lower courses can be removed and replaced without

disturbing the upper part of the wall. If the headers be not secured, the entire wall will have to be rebuilt.

The side and rear-end walls should always be double, with a two-inch air space, as shown in the cuts. The object of the air space is to prevent the leakage of heat as much as possible. The walls should not be bonded together, but there should be projecting bricks from the outer wall, extending in and touching the inner wall. This leaves the inner wall free to expand under the influence of heat, without affecting the outer one, and still leaves the latter in the position of a retaining wall.

It is advisable to line the entire setting with fire brick rather than only

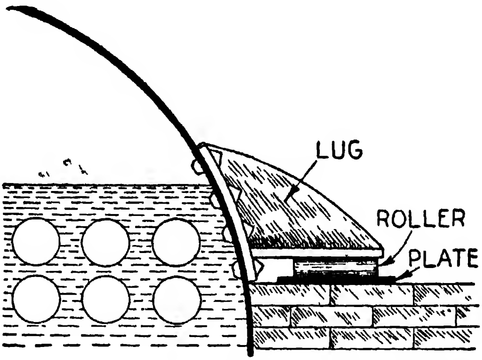


FIG. 4,385.—The usual but objectionable method of providing for expansion on lug supported boilers. *It will be seen* that no provision is made for tranverse expansion of the shell, consequently the sidewalls must "breathe" with the boiler, which tends to produce air leaks by cracking and loosening the mortar.

the furnace portion as is sometimes done. The reason for this is that a fully lined setting will stand up much longer and give far greater satisfaction under overload operation. The tendency of modern practice is to use fewer boilers and work them harder; hence, a fully lined setting is a good investment.

The better the quality of the fire brick used, the more economical the job will ultimately prove.

Mortar in Boiler Setting.—For the outer walls the mortar used should be composed of one part lime with four to six parts clean sand well screened and the joints should be as thin

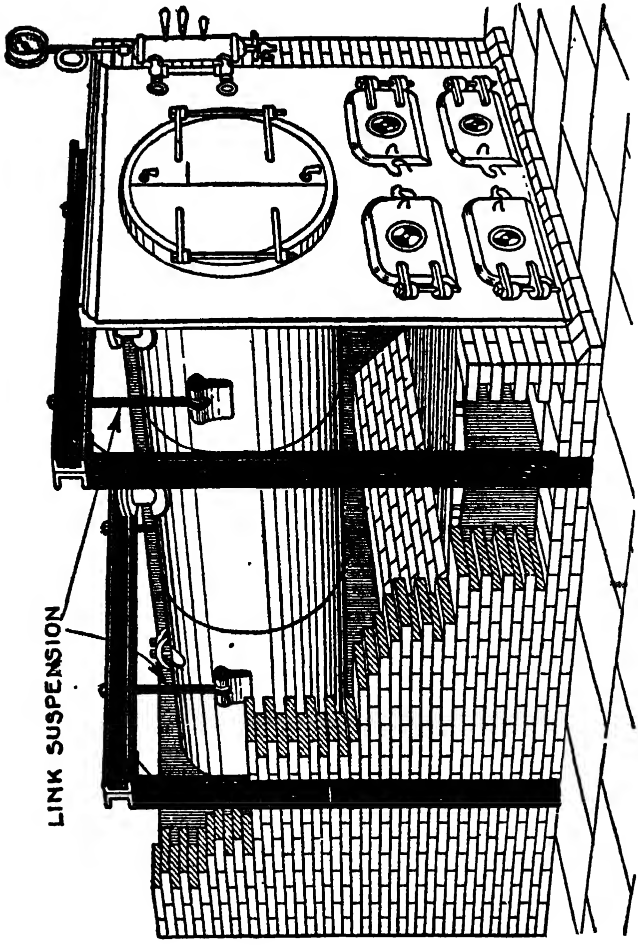


FIG. 4,386.—Method of providing for expansion by link suspension. As may be seen, the weight of the boiler is carried by the steel work, thus relieving the brick work of this duty. The side columns may be either of solid channel iron or built up from angles and lattice work, and channel bars are carried across the top of these columns as shown. The boiler is suspended from these channels by suspension links or rods arranged with nuts and washers, permitting easy leveling and adjustment of the height of the boiler.

as they can be laid, not over one-eighth of an inch thick, especially those exposed to the heat of the furnace.

The fire brick should be laid in contact with each other; a thin paste of fire clay, enough to fill up the irregularities of their surfaces and give them a solid bearing, being all the mortar that is admissible. In laying fire brick, each one should be dipped into water as it is used, so that it will not immediately drink up the water from the mortar. They should then receive a thin coating of the kaolin or fire clay, and be placed in position. The fire clay should be mixed up so thin that it cannot well be laid on with a trowel, an iron spoon being preferable.

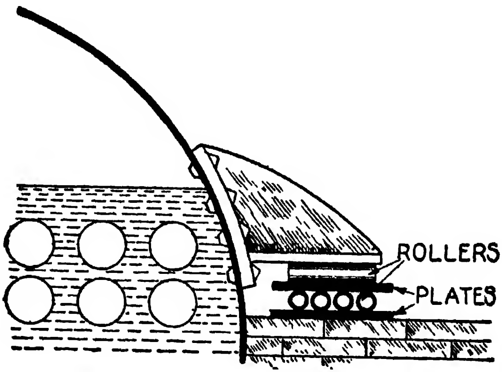


FIG. 4,387.—**Approved method of providing for expansion on lug supported boilers. The two sets of rollers placed at right angles to each other form a universal joint, allowing free movement both endwise or crosswise.**

Provision for Expansion.—Since boilers are longer (and larger in diameter) when hot than when cold it is necessary to provide: 1, space between the setting and boiler (as just mentioned), and 2, a flexible support to prevent cracking of the brick work.

When the boiler is supported by the brick work, expansion

Dimensions for Boiler Setting

Horsepower on a Basis of 10 Sq. Feet of Heating Surface per Horsepower: 3-inch Tubes	3½-inch Tubes	4-inch Tubes	Diameter of Boiler in Inches (A)	Length of Tubes, Feet (B)	Number of Tubes of Each Diameter	Thickness of Inside Furnace Walls, Inches (C)	Over-all Width of Setting, Feet and Inches (E)	Height from Floor Line to top of Setting Wall, Feet and Inches (F)	Thickness of Bridgewall Inches (G)	Width of top of Bridge-wall, Inches (H)	Top of Bridgewall to Shell of Boiler, Inches (I)	Top of Grates at Front to under side of shell, Inches (J)	Length of Furnace, Inches (K)	Width of Furnace, Inches (L)	Floor Line to Bottom of Shell at Front Inches (M)	Floor Line to Bottom of Shell at Rear, Inches (N)	Distance bet. tube sheet and Rear Wall, Inches (O)	Approx. wgt. of boiler and water with allowance for piping and brick covering on top of shell and flue, lbs	Approx. ratio between grate and heating surface when 3-inch tubes are used	Number of Fire-brick required to set one boiler	Number of Red-brick required to set one boiler	For Overhanging Fronts Only: Over-all length of Setting Walls at Floor Line, Feet and Inches (D)	For Flush Fronts Only: Depth of Smoke Box, Inches (P)	Thickness of Front Wall, Inches (Q)	Over-all Length of Setting Walls at Floor Line, Feet and Inches (R)	Thickness of Front Wall at Floor Line, Inches (S)
33	48	44	48	12	50-3"	17	8'-0"	8'-0"	21½	9	10	26	48	42	56	55	22	16,000	1 to 35	1900	12,500	15'-11"	15	17	16'-10"	21
					38-3½"																					
61	56	51	48	14	30-4"	17	8'-0"	8'-0"	21½	9	10	26	54	42	56	55	22	18 000	1 to 35	2100	14,000	17-11"	15	17	18'-10"	21
72	63	51	54	14	60-3"	17	8'-6"	8'-6"	21½	9	12	26	54	48	58	57	24	23,000	1 to 35	2200	15,500	18'-1"	16	18	19'-1"	22
					44-3½"																					
83	72	58	54	16	30-4"	17	8'-6"	8'-6"	21½	9	12	28	54	48	58	57	24	25,500	1 to 40	2500	16 500	20'-1"	16	18	21'-1"	22
99	88	86	60	16	72-3"	17	9'-0"	8'-8"	26	9	12	28	60	54	58	57	26	32 500	1 to 40	2600	17,000	20'-2"	16	18	21'-3"	22
					54-3½"																					
110	99	96	60	18	46-4"	17	9'-0"	8'-8"	26	9	12	28	66	54	58	57	26	35 500	1 to 40	2500	18,500	22'-3"	16	18	23'-3"	22
130	118	108	66	16	98-3"	17	9'-6"	9'-6"	26	14	12	30	72	60	60	59	26	38 000	1 to 40	2850	18,500	20'-3"	1	19	21'-4"	23
					74-3½"																					
147	132	121	66	18	60-4"	17	9'-6"	9'-6"	26	14	12	30	78	60	60	59	26	41 500	1 to 40	3100	20 000	22'-3"	17	19	23'-4"	23
163	149	131	72	16	124-3"	21½	10'-9"	9'-10"	30½	14	12	30	72	66	60	59	28	47,500	1 to 45	3050	23,500	20'-7"	18	20	21'-0"	24
183	167	147	72	18	96-3½"	21½	10'-9"	9'-10"	30½	14	12	30	84	66	60	59	28	51 000	1 to 45	3300	26 000	22'-7"	18	20	23'-9"	24
203	185	164	72	20	74-4"	21½	10'-9"	9'-10"	30½	14	12	30	90	66	60	59	28	56 000	1 to 45	3600	27,500	24'-7"	18	20	25'-9"	24
188	175	161	78	16	144-3"	21½	11'-3"	10'-6"	30½	14	12	34	72	72	64	63	28	50 000	1 to 50	3300	25,500	20-7"	20	22	21-11"	26
211	197	181	78	18	114-3½"	21½	11'-3"	10'-6"	30½	14	12	34	78	72	64	63	30	54 500	1 to 50	3600	27,500	22'-7"	20	22	23'-11"	26
234	218	201	78	20	92-4"	21½	11'-3"	10'-6"	30½	14	12	34	84	72	64	63	30	59 000	1 to 50	3900	29,500	24'-7"	20	22	25'-11"	26
260	242	221	84	18	180-3"	21½	12'-3"	11'-0"	30½	14	14	34	84	84	64	63	30	62,500	1 to 50	3850	29,000	22'-7"	20	22	23'-11"	26
					142-3½"																					
288	268	245	84	20	114-4"	21½	12'-3"	11'-0"	30½	14	14	34	90	84	64	63	30	68,000	1 to 50	4150	31,500	24'-7"	20	22	25'-11"	26
310	284	267	90	18	210-3"	21½	12'-9"	11'-4"	35	14	14	36	84	90	66	65	32	65,000	1 to 55	4000	20,500	22'-9"	22	24	24'-3"	28
					168-3½"																					
334	315	297	90	20	140-4"	21½	12'-9"	11'-4"	35	14	14	36	90	90	66	65	32	70 000	1 to 55	4350	33,000	24'-9"	22	24	26'-3"	28
353	320	302	96	18	248-3"	21½	13'-3"	11'-8"	35	14	14	36	84	96	66	65	34	70 000	1 to 55	4150	31,500	22'-9"	22	24	24'-3"	28
					190-3½"																					
[illegible]	[illegible]	[illegible]	96	20	158-4"	21½	13'-3"	11'-8"	35	14	14	36	90	96	66	65	34	76 000	1 to 60	4500	34 000	24'-9"	22	24	26'-3"	28

NOTE—In using this table for setting boilers, particular attention must be paid to the fact that dimensions F, J, M, and N must conform to the dimensions of the front furnished with the boiler and dimensions K and L with the grates furnished. On flush fronts, dimensions Q, R, and S depend on dimension P, and these dimensions must be changed to conform to any changes that may be necessary in P. The column giving the number of common brick required refers to the overhanging front style of setting, and for flush fronts there should be added 500 to 2500 brick, depending on the size of the boiler.

is usually provided for by placing rollers under the rear supporting legs as shown in figs. 4,385 and 4,387.

The reason for putting the rollers at the rear end instead of the front end is because the front end rests upon the brick work and accordingly should not move. The author objects to the arrangement shown in fig. 4,385, in that it does not provide for lateral expansion.

In bricking up around the lugs, a recess must be left large enough so that the lugs will not touch the brick work in any spot. In fact, the brick work should not touch the boiler at any point.

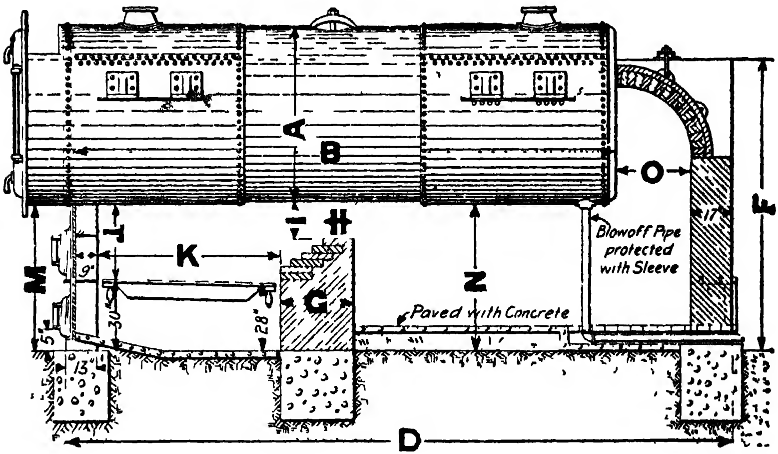
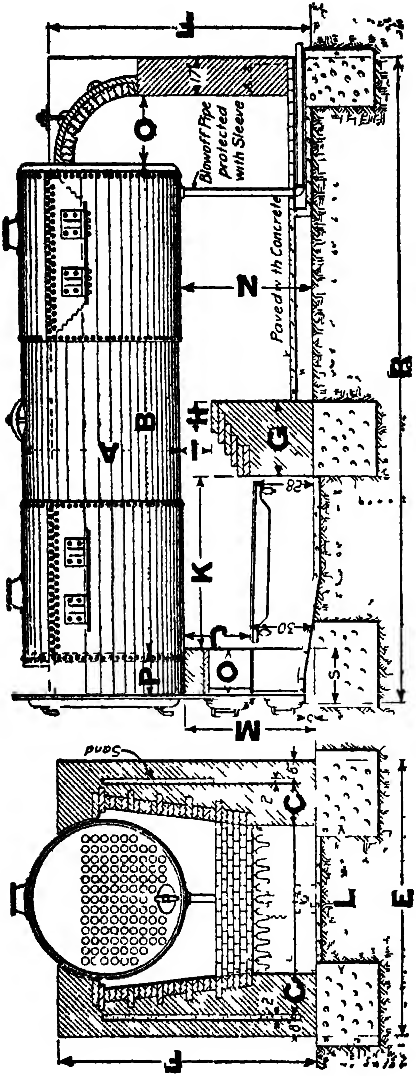


FIG 4,388.—Setting design for overhanging front boiler The dimension letters refer to the accompanying table of dimensions for boiler setting

The Grate.—This is set about 24 ins. above the floor level and should pitch backward 3 ins. to the bridge wall. This gives a thicker layer of coal at the rear end of the grate and thus promotes uniformity of combustion; because with a uniform layer of coal, the air will naturally pass through more freely at the rear.

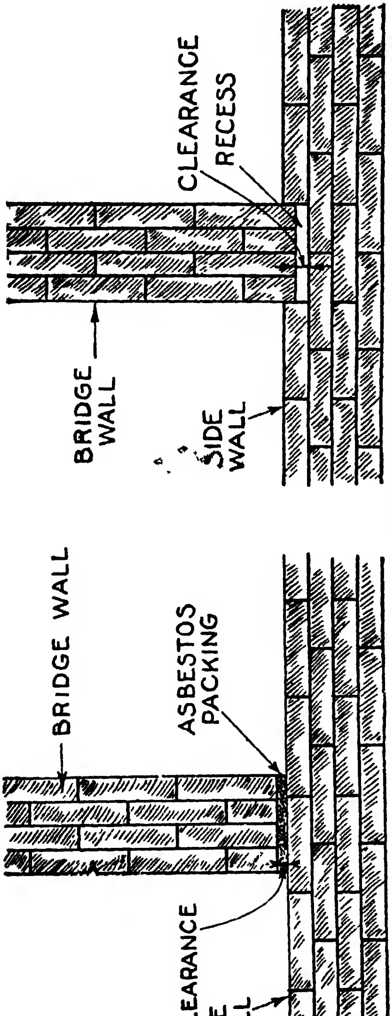


FIGS 4,389 and 4 390.—Setting design for flush front boiler. The dimension letters refer to the accompanying table of dimensions for boiler setting.

In addition, *the pitch makes slicing and firing easier.* The top of the front end of the grate is from 24 to 28 inches below the boiler shell, varying with the size of the boiler. The width of the grate should be six ins. less than the diameter of the boiler.

Bridge Wall.—This is a most important part of the setting. Unless it be located in the right place and be of the right thickness and height, more or less trouble may result in the way of overheated sheets, especially if there be a girth seam near.

The wall must be strong enough to withstand the thrust of the firing implements used in cleaning the fire, and must be thick enough that the joints do not loosen by this action.

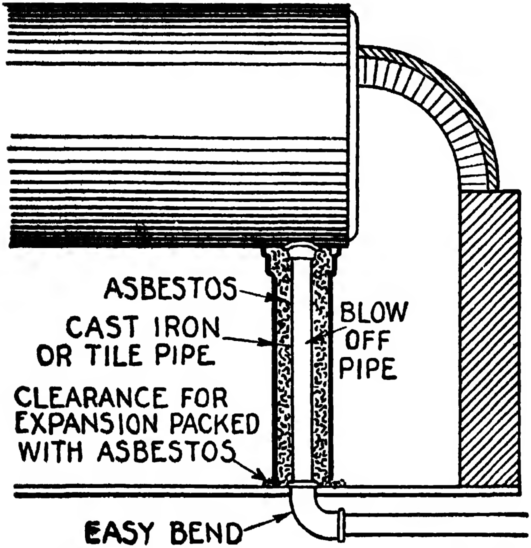


FIGS. 4,391 and 4,392.—Two methods of joining bridge wall to side walls to allow for expansion. The bridge wall may be built with a one-inch clearance space between its ends and the side walls, as in fig. 4,891, and this clearance packed with asbestos rope, or it may be extended into a recess in the side walls as in fig. 4,892 allowing a clearance of 1½ inches in the recess for expansion.

Experience shows that the best results are secured with a bridge wall perfectly flat on top as shown in fig. 4,389 and not built circular to follow the curve of the boiler shell. The distance between the bottom of the shell and the crest of the bridge wall should be not less than 10 inches. The crest of the wall should be one or one and a half fire brick lengths wide according to the table on page 322.

Each course below should be set out as shown in fig. 4,390, so that the front face slopes forward at an angle of about 45 degrees until the full thickness of the wall is reached.

The bricks on the sloping face and on the front of the crest should be laid as headers, as shown, in order that an accidental poke with a fire iron will not be likely to knock any off. Some engineers prefer that these brick be cut beveled on the front so as to present a smooth surface on the slope of the bridge wall. The bridge wall should be connected with the side walls as shown in fig. 4,391 or 4,392, so that it is free to expand. If this be not done, the expansion of the



bridge wall will crack out the side walls of the setting.

Combustion Chamber. — The space between the bridge wall and rear end of the boiler, commonly called the combustion chamber, may extend down to the floor line, or be reduced in size by a wall sloping from the top of the

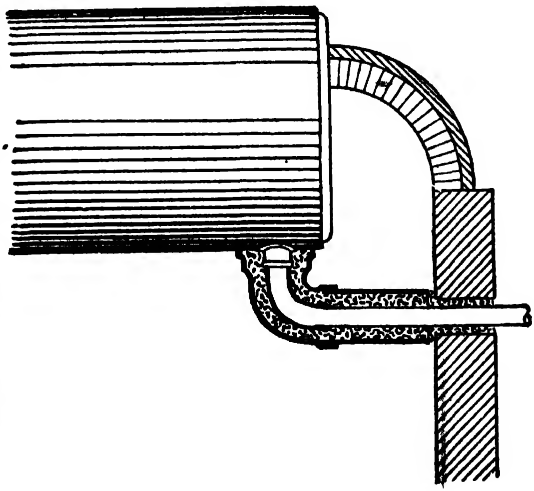


FIG. 4,393 and 4,394.—Two arrangements for the blow off connection. The first or vertical run is preferable, but for convenience, the pipe may be carried out horizontally above the floor line and will be satisfactory if properly protected. The object aimed at is to keep the pipe cool as possible preventing the formation of steam, and avoiding baking of the sediment in the pipe. Use easy bends instead of close elbows, and have the outer casing large enough for a liberal thickness of asbestos between casing and blow off pipe.

bridge wall to the floor level at the rear of the boiler.

In the rear end of the combustion chamber provision must be made to protect the blow off pipe from the intense heat to prevent the formation of steam in the pipe. This is done by covering the pipe with asbestos, the pipe and asbestos being encased in a large cast iron or tile pipe, as shown in figs. 4,393 and 4,394.

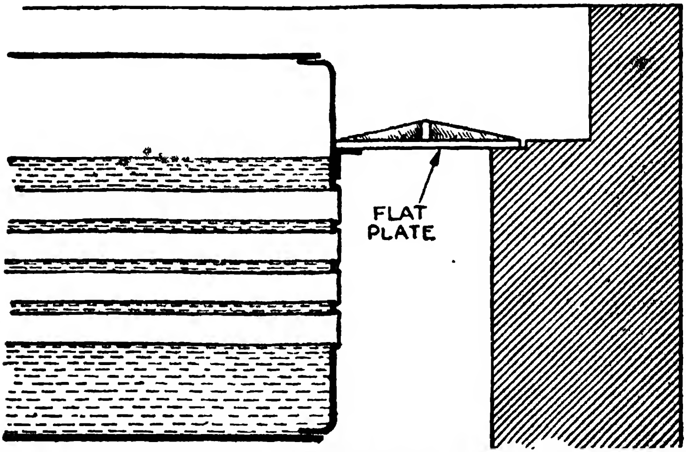


FIG. 4,395 —Flat plate back connections. This construction affords easy access to the back end of the boiler and plenty of light but is objectionable in that *the metal is not protected from the heat.*

Back Connection.—The opening between the back wall and rear end of the boiler is covered either by a flat plate or some form of arch construction.

Fig. 4,395 shows the flat plate connection. Such arrangement lasts but a short while because the iron quickly burns out.

Another construction is to spring a long span arch between the side walls as shown in fig. 4,397. This arch must be almost flat so that it will not extend above the water line nor block off too many of the tubes at the sides. On account of being almost flat it is structurally weak. It must be

very carefully made in the first place and even at that it will not last very long, especially if the boiler must be forced occasionally.

The best construction is to spring a half arch between the back wall of the setting and the boiler shell as illustrated in fig. 4,396.

The joints of back connections must be made tight by covering with earth or equivalent, otherwise cold air will enter and lower the temperature of the gases passing through the tubes.

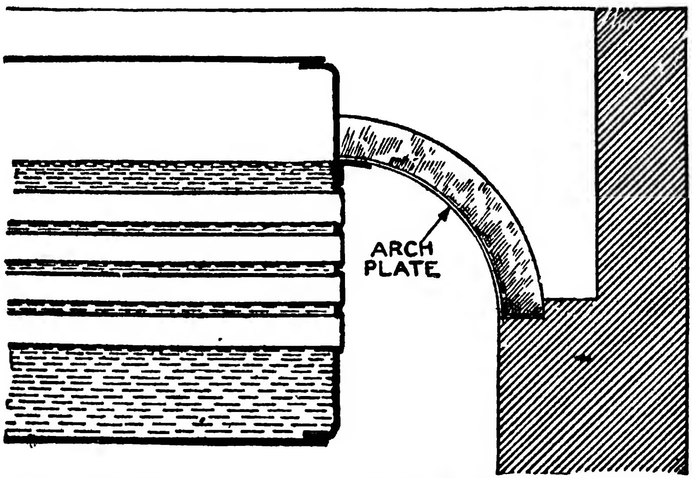


FIG. 4,396.—Ordinary arch back connection with *inside* cast iron arch plate. *The objection* to this construction is that the cast iron plate is exposed to the intense heat.

Top Covering.—The usual but questionable method of constructing the top of a boiler setting is to cover the top of the boiler with some form of insulating material. There are three methods of doing this:

1. When the brick are laid coat them over with a grout of one part cement and one part sand to a thickness of at least ¼ inch. Although this is the cheapest and probably the most durable construction, it has but slight value for heat insulation.

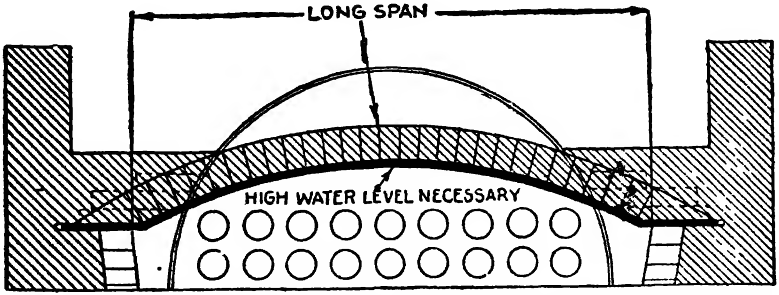
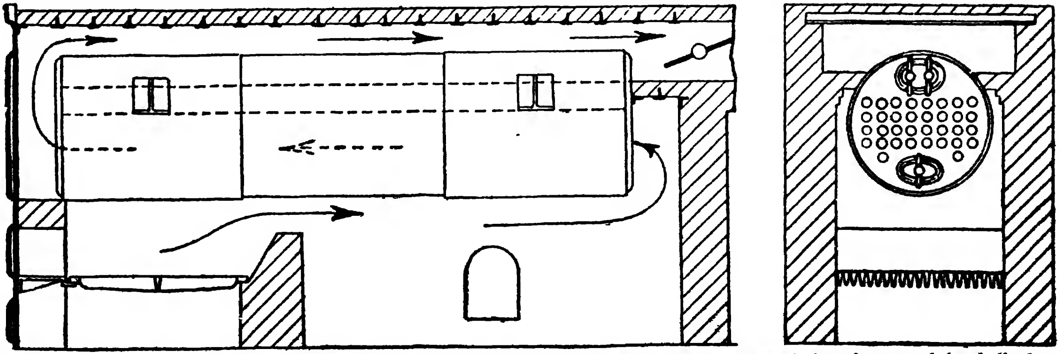


FIG. 4,397.—Long span arch back connection. ***In this construction*** the arch springs from the two side walls, and of necessity must be almost flat. It is objectionable because: 1, its almost flat shape is an element of weakness, and 2, a higher water level must be carried.

2 A more efficient method in this respect and one which is also fairly cheap is the use of a good grade of asbestos in fairly thick layers.

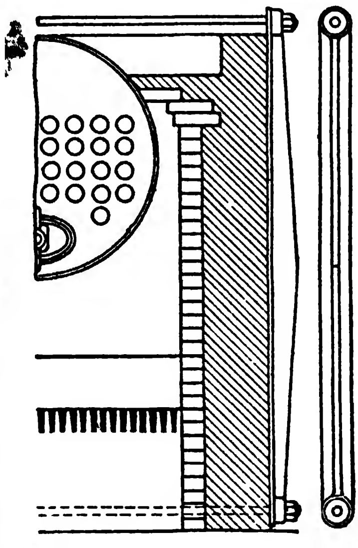
3 The best covering to use from the heat saving point of view is 85 per cent. magnesia, 2 or 3 inches thick, finished off with a hard cement layer on the outside.



FIGS. 4,398 and 4,399.—Boiler setting with jacketted top covering; the correct method of enclosing the top of the shell when economy is of any consequence. As will be seen, the hot gases after passing through the combustion chamber and tubes, traverse the top of the shell, thus avoiding the heat loss through the ordinary top covering.

A more sensible and advanced method of treating the top is to jacket it as shown in figs. 4,398 and 4,399, thus insulating the top with a sheet of hot gases passing off from the tubes.

Buck Staves.—In order to prevent the spreading of the furnace walls, they are reinforced by cast iron upright members known as buck stays, as shown in figs. 4,400 and 4,401. These



FIGS. 4,400 and 4,401.—*Buck stave* or reinforcing member for boiler setting *As shown*, the buck staves arranged in pairs are held firmly in place against the brick work by stay rods, which extend from side to side of the furnace at top and bottom Buck staves are commonly made of cast iron. Their use is to prevent the spreading of the furnace walls and they should accordingly be rigid To secure rigidity the web should be from 4 to 6 inches deep. Buck staves are usually placed 4 to 5 feet apart on the side walls.

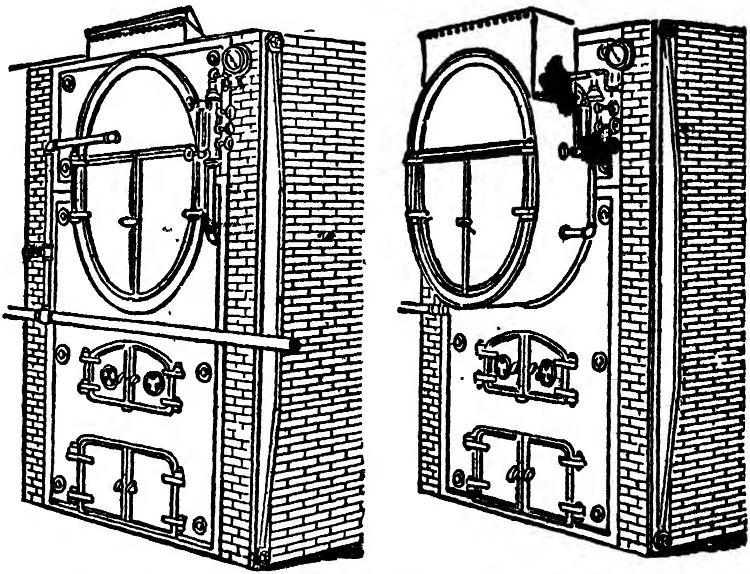
are of T shape and for proper stiffness the web should be from 4 to 6 inches deep, depending on the diameter of the boiler. They are usually placed 4 or 5 feet apart on the side walls.

Boiler Fronts.—These are made in many different styles, almost every maker having some peculiar points in design.

There are four general types:

1. Flush front.
2. Overhanging front.
3. Cutaway front.
4. Breaches front.

These various fronts are shown in figs. 4,402 to 4.405. The flush front is the oldest type.

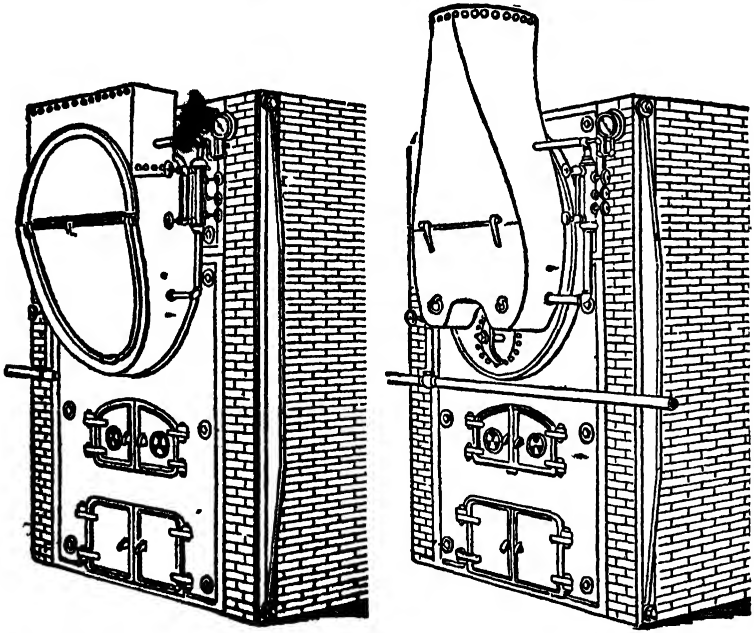


FIGS. 4,402 and 4,403.—Various boiler fronts. Fig. 4,402, flush front; fig. 4,403, overhanging front.

An objection is that the heat from the fire, striking through the brick work, impinges on this sheet, which is unprotected by water on the inside. So long as the furnace walls are in proper condition the heat thus transmitted should not be sufficient to give trouble; but after running some time bricks are very apt to fall away from over the fire door, and thus

expose portions of the dry sheet to the direct action of the fire, causing it to be burned or otherwise injured by the heat, and perhaps starting a leak around the front row of rivets when the head is attached to the shell.

In the overhanging front, as shown in fig. 4,403, this tendency is prevented by setting the boiler *in such a manner that the dry*



FIGS. 4,404 and 4,405 —Various boiler fronts. Fig 4 404, cut-away front; fig 4,405, breeches front for man hole.

sheet projects out into the boiler room. An objection to the overhanging front is that it is in the way of the fireman. To meet this point and yet preserve all the advantages of this kind of front, the cut away style, shown in fig. 4,404, has come into use. The front shown in fig. 4,405 consists of sheet

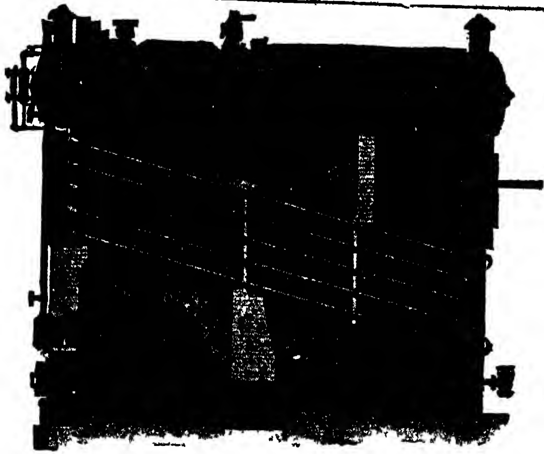


FIG. 4,406.—Babcock and Wilcox water tube boiler and setting. ***Vertical header*** type.

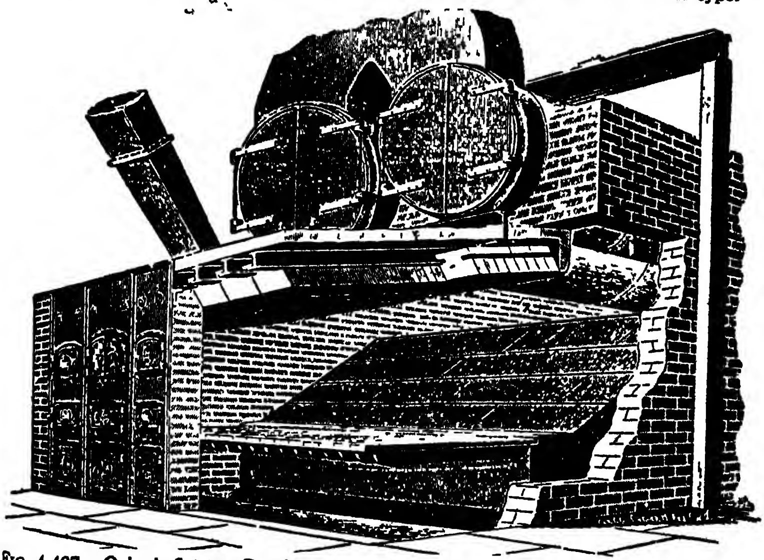


FIG. 4,407.—Quinn's flat top Dutch oven furnace setting (Walsh and Weidner). ***This type*** of furnace is especially fitted for Dutch ovens burning damp or bulky fuel. There are two layers of tile with the air space between for cooling the suspension beams and the tile.

iron breeching that comes down over the timber, leaving the manhole exposed where it is accessible.

Bricks Required for a Setting.—To estimate the number of brick in a wall, multiply the length of the wall by the width and height all in inches, and divide by 82 for common brick, or by 116 for fire brick. The quotient will be approximately the number required.

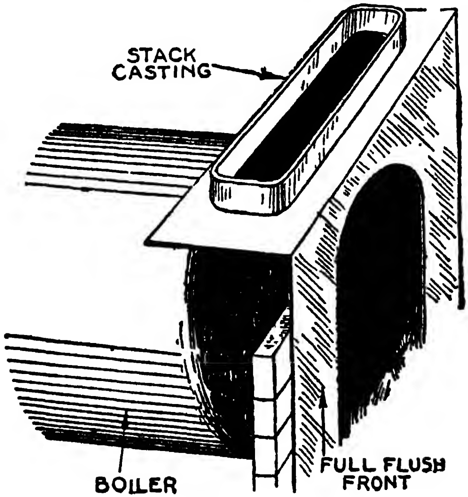


FIG. 4,408.—Stack plate casting for flush end boiler, full flush front. The smoke box is formed by the brickwork of the setting.

If the lining of the furnace is to be made all headers, as already mentioned, multiply the fire brick required for that part of the wall by 2.6, or multiply the area to be laid in square feet by 12.

In estimating the material needed for a boiler setting, 250 pounds of lump lime and 1 cubic yard of sand will be required for each thousand bricks in the walls, and from 800 to 900 pounds of fire clay for each thousand fire brick in furnace linings.

CHAPTER 78

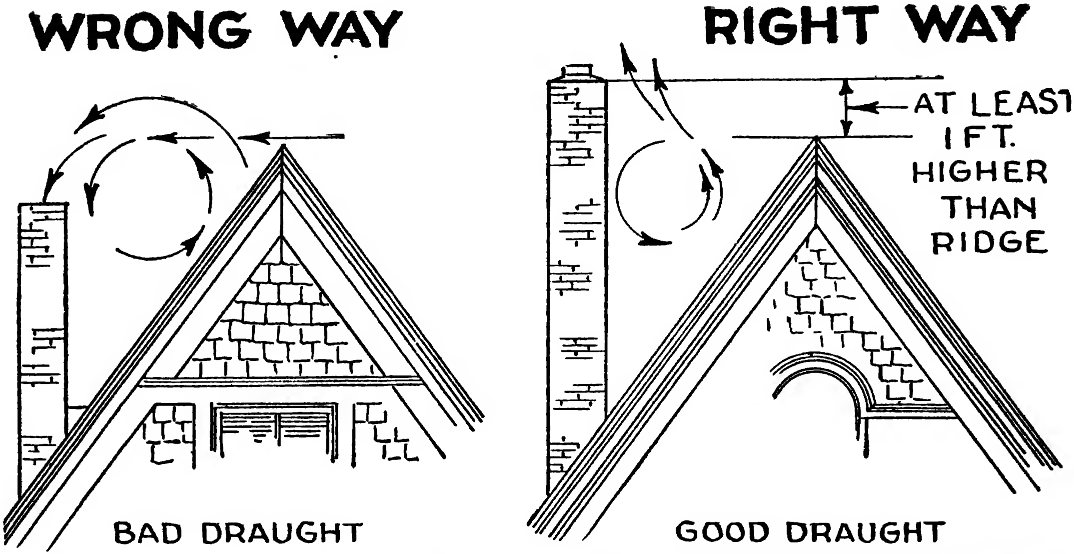
Chimneys

The term chimney as here used includes both the chimney proper and, in house construction, the fire place. There is no part of a house that is more liable to be a source of trouble, when improperly constructed, than a chimney. Accordingly, it should be so built that it will be mechanically strong, and properly shaped and proportioned to give adequate draught.

For strength, chimneys should be built of solid brickwork and should have no openings except those required for the heating apparatus.

If a chimney fire occur, considerable heat may be engendered in the chimney, and the safety of the house will then depend upon the integrity of the flue wall. It is dangerous to use hollow units for this purpose, for these cannot stand high temperatures without danger of cracking and spalling. The chimney may, though it need not be a point of danger. A little intelligent care in its construction will prove to be the best insurance. As a first precaution, all wood framing of floor and roof must be kept at least 2 inches away from the chimney and no other wood work of any kind be projected into the brickwork surrounding the flues.

Conditions for Good Draught.—When it is understood that the only motive power available to produce a (natural) draught in a chimney is that due to the small difference in weight of the column of hot gases in the chimney and of a similar column of cold air outside, the necessity of properly constructing the



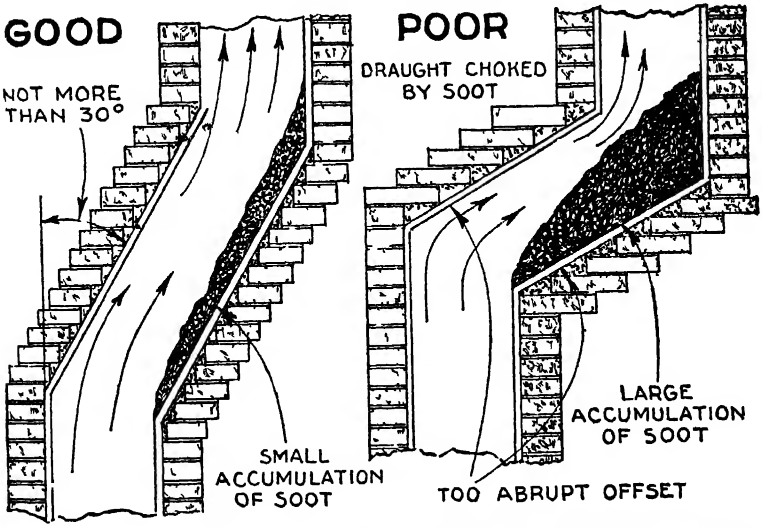
FIGS 4,409 and 4,410—Wrong and right way to build chimney. *To avoid poor draught* by eddy currents from roof *the chimney should extend at least one ft higher than the roof*

chimney so that the flow of gases will encounter the least resistance must be apparent.

The intensity of chimney draught is measured in inches of a water column sustained by the pressure produced and depends on: 1, the difference in temperature inside and outside of the chimney, and 2, upon the height of the chimney.

A frequent cause of poor draught in house chimneys is that the peak of the roof extends higher than the chimney. In such case the wind sweeping across or against the roof will form eddy currents that drive down the chimney or check the natural rise of the gases as in fig. 4,409. To avoid this the chimney should be extended at least one ft. higher than the roof, as shown in fig. 4,410.

In order to reduce to a minimum the resistance or friction due to the



Figs 4 411 and 4 412 —Easy and abrupt offsets *No offset should be inclined more than 30° to the vertical* If too abrupt, the conditions shown in fig 4 412 will result

chimney walls the chimney should run as near straight as possible from bottom to top This not only gives better draught but facilitates cleaning. If, however, offsets are necessary from one story to another, they should be very gradual, never less than at an angle of 30° from the vertical, as in fig 4,411 If abrupt offsets occur in flues, soot will soon be deposited, choking the flue, as shown in fig. 4,412, and making cleaning almost impossible

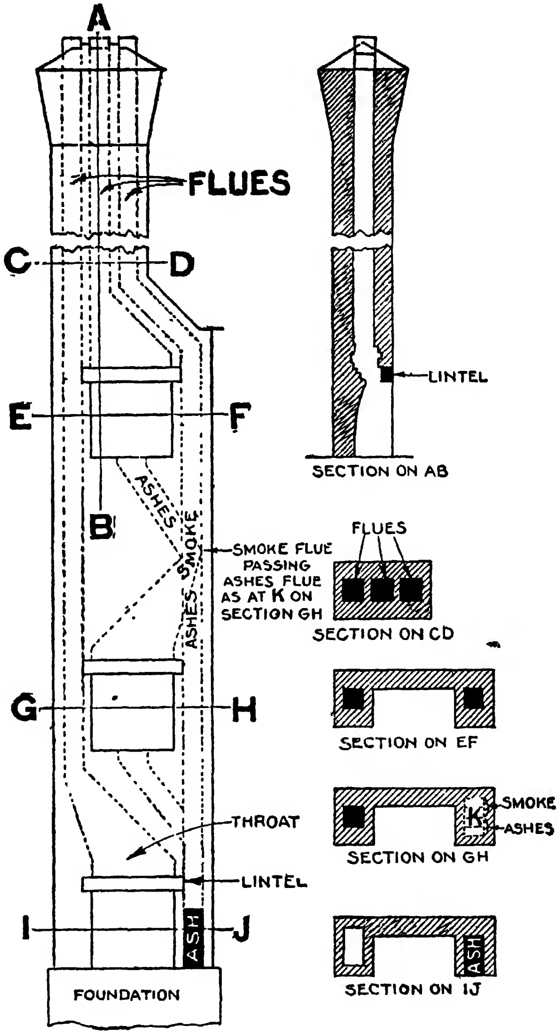
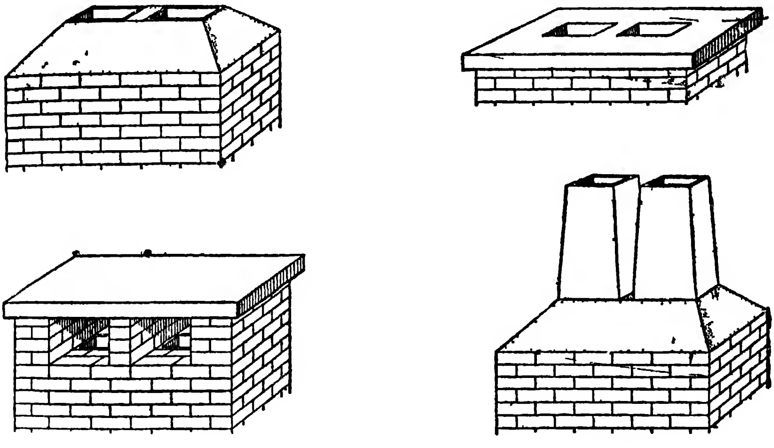


FIG. 4,413 to 4,418.—General arrangement of ordinary house chimney serving three fire places. The sections at various points give a good idea of the construction of the chimney.

Chimneys erected on the interior of a building are apt to be more efficient because the warm air surrounding them facilitates the draught while those located on the exterior naturally are somewhat affected by the cool air on the outside.

To improve the draught of chimneys already built or to provide an artistic finish for new chimneys, there is a variety of chimney pots of various designs available. The most durable and sightly chimney pots are those of burned clay.



FIGS 4 419 to 4,422 —Capping for chimney tops. FIG 4,419, cement cap sloping away from projecting flue linings, and tending to counteract eddy currents from roof, fig 4,420, New York style of stone cap with hole same size as caps, fig 4,421 solid stone caps with side openings fig 4,422, projecting flue with sloping cement bedding being both ornamental and efficient.

Flues.—A chimney serving two or more floors should have a separate flue for every fireplace. The method of building these flues is shown in fig. 4,413, the arrangement of these flues being further shown in figs. 4,414 to 4,418. The flues should always be lined with some fireproof material. In fact, the building laws of large cities provide for this. The least

expensive way to build these is to make the walls 4″ thick, lined with burned clay flue lining. With walls of this thickness never omit the lining or replace it with plaster. The expansion and contraction of the chimney would cause the plaster to crack and an opening from the interior of the flue formed. See that all joints are completely filled with mortar.

If flue lining be not used, the walls should be not less than 8″ thick, with joints in the flue carefully pointed. In Europe, a mixture of cow dung and

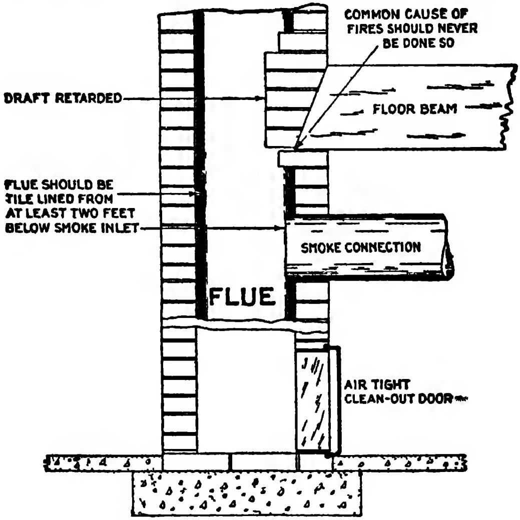
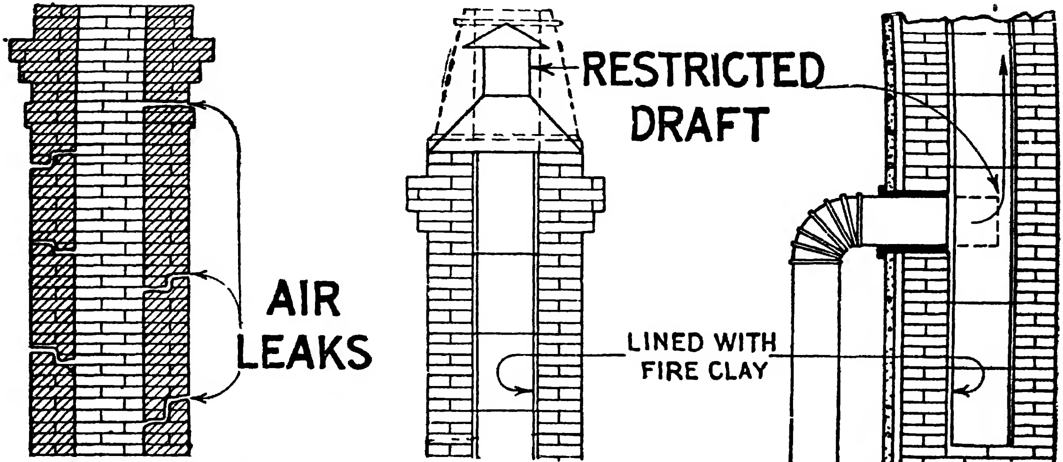


FIG 4,423 —Clean out door set in mortar and carefully fitted, it should be installed at the base of the chimney

lime plaster is used for plastering flues, and is found to crack but little The plaster is applied as the flue goes up. A bag of shavings fitting the flue tightly may be drawn up by a rope attached to the top of the bag as the flue is built to catch the plaster droppings The latter is not only useful but very important also in a flue in which clay lining is used, and in which there is an offset, and may save much trouble and cost to contractors in cleaning out flues after completion.

The flue lining should extend the entire height of the chimney, projecting about 4 in. above the cap and a slope formed of cement to within 2″



FIGS. 4,424 to 4,426.—Draught checkers often met with. In fig. 4,424, defective or broken mortar joints admit cold air and check draught. The fitting of a cap smaller than the flue restricts the draught by diminishing the flue area. Similarly a smoke pipe pushed in too far so that it projects into the flue space as shown by the dotted lines will choke the draught.

of the top of the lining as shown in fig. 4,419. This helps to give an upward direction to the wind currents about the top of the flue and tends to prevent rain and snow from being blown in. Some other methods of capping chimney tops are shown in figs. 4,420 to 4,422. The flue space should not extend up from the foundation but only about a foot below the first connection. The furnace flue should have a cleanout door as shown in fig. 4,423. Be careful that there is no connection between the flues at the bottom or trouble may be experienced with the draft. Fill all the joints of the flue lining and the space between the lining and the brickwork tightly with mortar.

If the flues be not lined they are generally built for coal smoke flues 8×8 inches or 8×12 inches inside measurement or a brick wide and a brick and a half long, and a partition, one brick thick, is carried up between them.

The illustration shows the section in detail of the full brick construction of a modern chimney breast, built on the 5th floor of an apartment house. The side or gable wall is 12 inches thick and the chimney, containing 5 flues, is projected into the room 8 inches, which is done for the purpose of obtaining 8 inches of brickwork on the outside or face of the wall for necessary strength. This projection is termed the "chimney breast," and is necessary

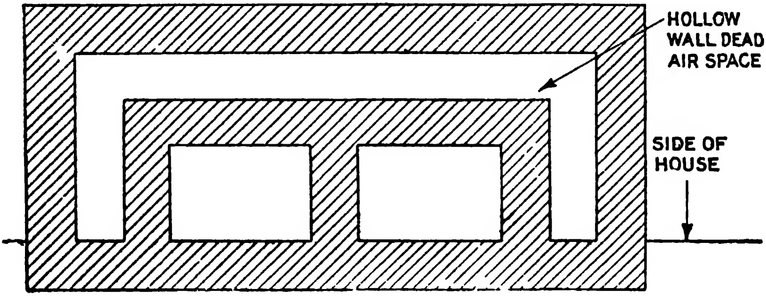


FIG. 4,427 —How to build an outside chimney for a cold climate so that the flues will not be unduly chilled.

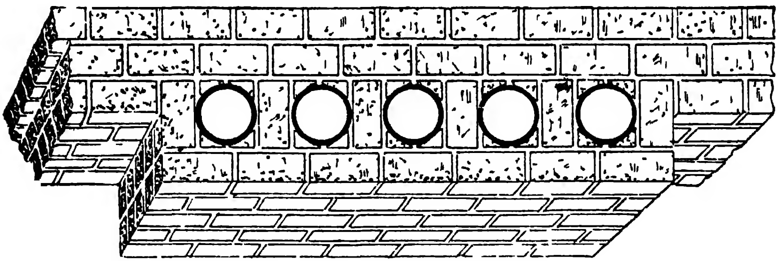
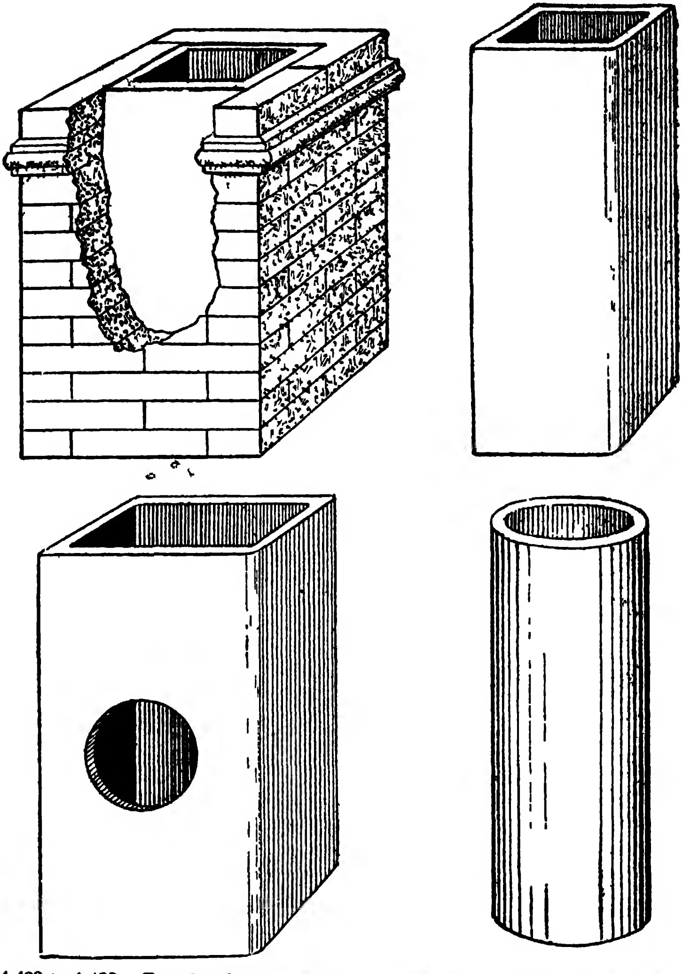


FIG 4,428.—Detail of chimney breast showing round flue linings.

to contain the flues. It will be observed that the flues are lined with fire clay or terra cotta "linings," which are short lengths of cylindrical shape, set end on end, from the mouth or intake of each flue at the bottom to the outlet at the chimney top, thus forming a clean, smooth conduit for the fire and smoke from stove or fireplace to the outer air.

Flues may be either round or rectangular in cross section,



FIGS 4,429 to 4,432.—Fire clay flue linings, they are superior to metal as conductors of hot air, and will carry the heat with less loss from radiation; are safer, being made of non-conducting materials, and will not transmit the heat to wood coming in contact with them; are cheaper and more durable, are used for chimney linings, for partitions in chimneys, for conducting hot and cold air, for ventilation, etc They may be obtained with register pipe opening as shown in fig 4 431, or in other odd shapes.

as shown in figs. 4,429 to 4,432. They come from 20 to 30 inches long.

The most efficient shape of flue is a round flue, next to that a square flue. Currents in a chimney rise with a circular swirling motion.

Modern heating plants necessitate accurate construction of chimneys, and most manufacturers of heating apparatus nowadays recommend the area and height of the flue necessary for their installations. The following table will prove useful in considering the question of heating plant or fire-place, by showing the dimensions of flue linings to be ordered when the required area is ascertained.

Rectangular and Round Flue Linings

(All flues made without collars in two ft. lengths)

Rectangular flues outside dimensions	net inside area	***Round flues*** inside diameter	net inside area
4½ in. × 8½ in.		6 inches	28 3
4½ " ×13 "		7 "	38 5
4½ " ×18 "		8 "	50.3
8½ " × 8½ "	52 sq. in.	9 "	63 6
8½ " ×13 "	80 " "	10 "	78 5
8½ " ×18 "		12 "	113
13 " ×13 "	126 " "	15 "	176 7
13 " ×18 "	169 " "	18 "	254 5
18 " ×18 "	240 " "	20 "	314.2
		24 "	452 4

Not less than 8 ins. of brickwork and an air space is necessary between smoke flues and wooden beams to obviate all possibility of the beams igniting and causing a fire.

Mistakes are often made in constructing flues through not carrying the offset "fast enough" to the right or left, as the case may be, so as to prepare for the fireplace above, then, when the mistake is discovered, they are carried over quickly, and a nearly horizontal surface is formed resulting in a faulty flue.

Large Chimneys.—For large power houses and other industrial uses, chimneys of considerable magnitude (as compared with house chimneys) are built, their proper design requiring engineering skill. The matter on these chimneys which follows is in accordance with the recommendations of the American Chimney Corporation.

Foundations.—The depth of the foundation should be approximately $^1/_{25}$ of the height of the chimney, but never less than 4 ft.

The ideal cross-section would be a circular one. On account of the difficulty in building round forms, however, foundations are generally made octagonal. The width of the bottom slab should be made approximately equal to $^1/_{10}$ of the height of the chimney plus its clear diameter at the top. It should taper off to a width approximately one foot greater than the stack at its base. The resultant maximum compressive stresses will be found to be approximately three tons per square foot, suitable for sand or gravel bottoms.

Walls.—The thickness in inches of the brick wall at the bottom of the chimney should be at least equal to

$$\frac{\text{Height of Chimney in Feet}}{9} + 7''$$

It should gradually decrease towards the top of the chimney to 7″ for chimneys of less than 7′ in diameter, to 8″ for chimneys 7 to 10′ in diameter and to 10″ for chimneys of larger diameter.

NOTE.—During the building of a chimney, pieces of brick and lumps of mortar will drop in the flue, hence a hole should be left at the bottom, with a board put on a slant to catch the falling mortar. After the chimney is topped out the board and mortar can be removed and the hole bricked up. Where bends occur in the flue openings should be left in the wall to clean out any pieces of brick or mortar that may have lodged there.

The taper of the chimney should be approximately 4′ for every 100′ height.

Sections should not exceed 20′ in height.

Lining.—A lining should be provided, equal in height to approximately $^1/_5$ of the total height of the chimney in case of boiler plants. It should be equal to at least ½ of the height of the chimney for stacks carrying temperatures of 800 to 1,200° and a high grade fire-brick lining for the entire height is necessary in case temperature exceeds 1,500°.

The lining should start two feet below bottom of flue opening. If there be danger that combustible material may be carried over into the chimney and be ignited there, the lining should start at the top of the foundation.

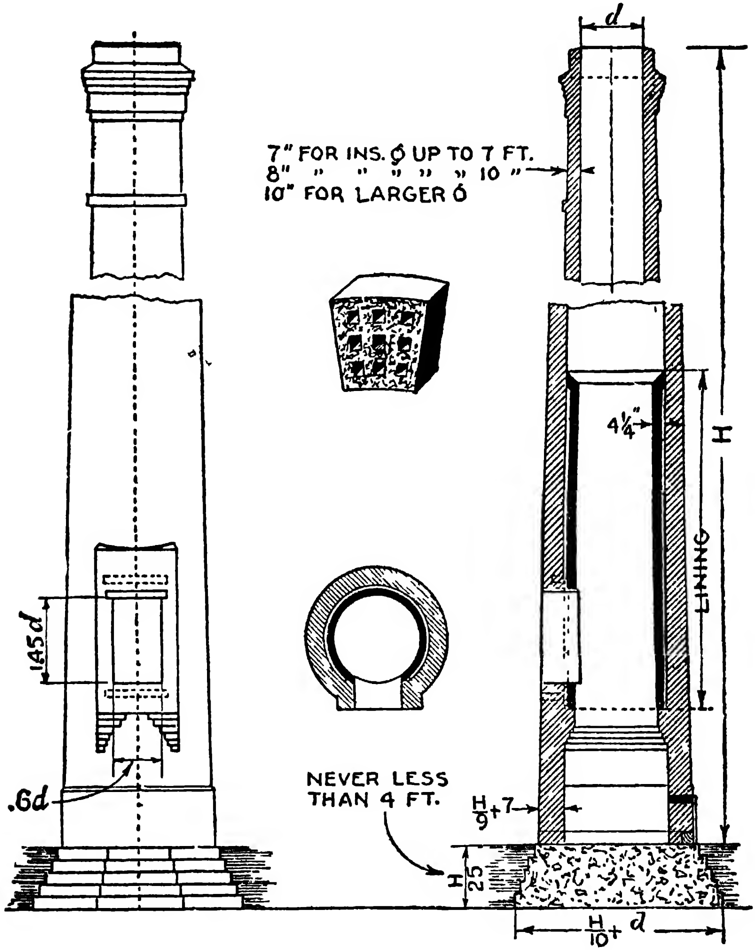
Flue.—The area of the flue should be approximately 10% larger than the clear area of the chimney at the top

Let D = clear diameter of the chimney at the top. Satisfactory results in regard to draft hindrances as well as stability are obtained by making:

$$\text{Width of flue} = .6\ D$$
$$\text{Height of flue} = 1.45\ D$$

The I-beams over the top of the flue should be carefully protected by a masonry arch with ample clearance between I-beams and arch to take care of expansion.

Lightning-Rod.—The lightning rod should be of such design that a point should be provided for every 3′ circumference at the top of the chimney. The points should be made of copper and should not extend more than four or five inches above top of the chimney as a protection against the effects of acid gases and to avoid swaying in the wind, resulting in a quick loosening



FIGS. 4,433 to 4,436.—Construction of radial brick chimney showing proportion of parts.

of the anchors. The cable should be at least 7/16″ thick and the earth terminal should consist of a copper cylinder of at least 4 square feet contact surface.

Radial Bricks.—The radial bricks to be used should weigh not less than 120 lbs. per cubic foot when laid in the wall, and their perforations should not exceed 25% of the area of the brick. Each perforation should not exceed one square inch in area as otherwise in laying the bricks the perforations will be entirely filled up with mortar, defeating the purpose for which they were arranged. The water absorption of the brick should be between 8 and 10%.

Fittings.—Steel bands should be provided at least at the top and above and below the flue opening. They should be at least of 3/8″ x 2½″ stock.

Step rungs should be of ¾″ round iron with hooks at the end to secure them in the walls. They should be placed not more than 16″ apart. An inside ladder is preferable to an outside one.

Chimneys should be provided with a sectional cast iron cap, especially in cases when they are operated periodically.

Common Brick Chimneys.—Their general design is the same as for radial brick chimneys. Under no circumstances should the top wall be made less than 8″

Sections are generally made 30′ long, increasing at each interval by one-half brick, that is, 4″.

Theoretical Draft in Inches of Water at Sea Level.—

Let

D = Theoretical draft.
H = Distance from top of chimney to grates.
T = Temperature of air outside of chimney.
T_1 = Temperature of gases in the chimney.

Then

$$D = 7.00\, H \left(\frac{1}{461+T} - \frac{1}{461+T_1} \right)$$

The results obtained represent the theoretical draft at sea level.

For higher altitudes they are subject to correction, as follows:

For altitudes of	Multiply with
1000′	0.966
2000′	0.932
3000′	0.900
5000′	0.840
10000′	0.694

Repairing Chimneys.—When a chimney is damp, examine the flashing at the junction with the roof, especially if wet spots appear on the ceilings of rooms. If the flashing be sound, possibly water runs down the inside of the flue and through defective mortar joints. Where these cannot be reached readily, the chimney may have to be torn down and rebuilt. Some times a hood is built on top of the chimney to keep out water or to prevent wind blowing down it.

To prevent dampness being drawn up from the ground, the mortar can be raked from a joint at least 12 inches above the

ground and a layer of slate, asbestos shingles or rust-resistant sheet metal and new mortar worked into the joint. This work should preferably be done by a mason. If bricks are porus or eroded, raking out the mortar one-half of an inch deep and applying three-fourths of an inch of cemnet plaster to the surfaces is effective. Eroded joints in the rest of the masonry should be raked and repointed.

Where natural gas is burned, dampness due to condensation is not unusual and a drain may be needed. Where such conditions exist, advice should be sought from the manufacturers of the equipment as to the proper remedy.

A chimney that becomes too hot to permit holding the hand against it should be carefully inspected by a reliable mason and adequately protected. If after a chimney be cleaned, an examination discloses holes, unfilled joints, or other unsound conditions out of reach for repair, it is advisable to tear the masonry down and rebuild properly.

Inside bricks that are impregnated with creosote and soot should not be used in the new work because they will stain plaster whenever dampness occurs. It is almost impossible to remove creosote and soot stains on plaster and wall paper. Sometimes painting the plaster with aluminum paint or waterproof varnish hides the stains.

A hatchway cut through a roof is convenient when high chimneys are repaired or cleaned, especially when access to the roof is difficult. The hatchway should be located so that it will not be necessary to crawl over the roof to reach the chimney and so that a ladder placed on the attic floor will not be too steep for safe ascent. A watertight cover with hooks to prevent its blowing off is essential. Such a hatchway is best provided when the building is erected but can be readily built at any time.

CHAPTER 78A

Fireplaces

Historical Data.—The fireplace dates back to the earliest history of man. The first home fires, forerunners to the modern fireplace, were those kindled on the earth or upon a conveniently placed slab stone, around which the family gathered to prepare its food.

In just what period in our history fires were first used will perhaps never be known, but we have evidence that primitive man made use of caves in his first temporary dwelling and built fires at the mount of these caves not only to prepare food, but also to protect his family from enemies.

Later, when dwellings were constructed outside of caves, family life centered in one large room in the middle of which a wood fire was lighted. Here the smoke was allowed to escape as best as it could through a hole in the roof or crevices in the wall. This use of fire for heating and cooking was adopted even by the nomads, who built fires in the center of their tents and allowed the smoke to escape through a prepared opening at the top.

As more permanent and larger habitations were built and balconies or second floors were used for sleeping quarters, the hearth-stone was moved to the corner of the room and an opening made in the wall to allow the smoke to escape. Later a stone hood, which sloped back against the wall was added to aid in carrying the smoke out of the building.

Gradually the efficiency of the open fire was increased and eventually the fireplace was constructed in a recess in the center of one of the walls, with its own hood and enclosed flue, leading up to a chimney on top of the wall. As time passed, and more consideration was given to the comforts of living, the fireplace was not only improved, but became the central decorative feature of the home.

The value of fireplaces was appreciated in *England* as early as the latter part of the fourteenth century, when they became an ornamental feature in the better homes. *Count Rumford*, an English scientist who published a series of essays on chimneys and fireplaces in 1796, is the one to whom we are most indebted for the improvement in fireplace design and for the rules governing the openings and flues. He spent a great deal of time studying the errors of fireplace construction and the principles governing the circulation of gases and combustion.

Count Rumford also gave considerable time to the reconstruction of old fireplaces in accordance with the principles he had developed.

Among these principles are the following:

Bringing the back of the fireplace forward and splaying the sides so that a greater amount of heat may be reflected into the room; preventing the loss of some of the heat through the flue in the chimney by narrowing the throat opening in the smoke chamber and placing this opening near the front; and dropping the lintel when it was too high to improve the circulation of gases in the smoke chamber.

The rules that Count Rumford laid down in a general way are the bases of the most successful types of modern fireplace construction.

Near the end of the 19th Century other means of heating dwellings besides the fireplace came into use. The fireplace lost some of its prestige as a heating medium, but was included in dwelling construction, chiefly on account of its decorative appearance and its cheerful associations. On the other hand, the fireplace, as it was developed by American architects, during the past 50 years, has become one of the most ornamental and beautiful features of the home.

Probably in no other country have so many types and styles of fireplaces been constructed as in the United States. Various fireplace mantels are illustrated in figs. 1 to 13. Although the ornamental mantel facings of fireplaces may be of other materials than brick, the chimney and its foundations are invariably of masonry construction. Figs. 1 to 4 shows an elevation and cross section of a fireplace and chimney stack suitable for the average home.

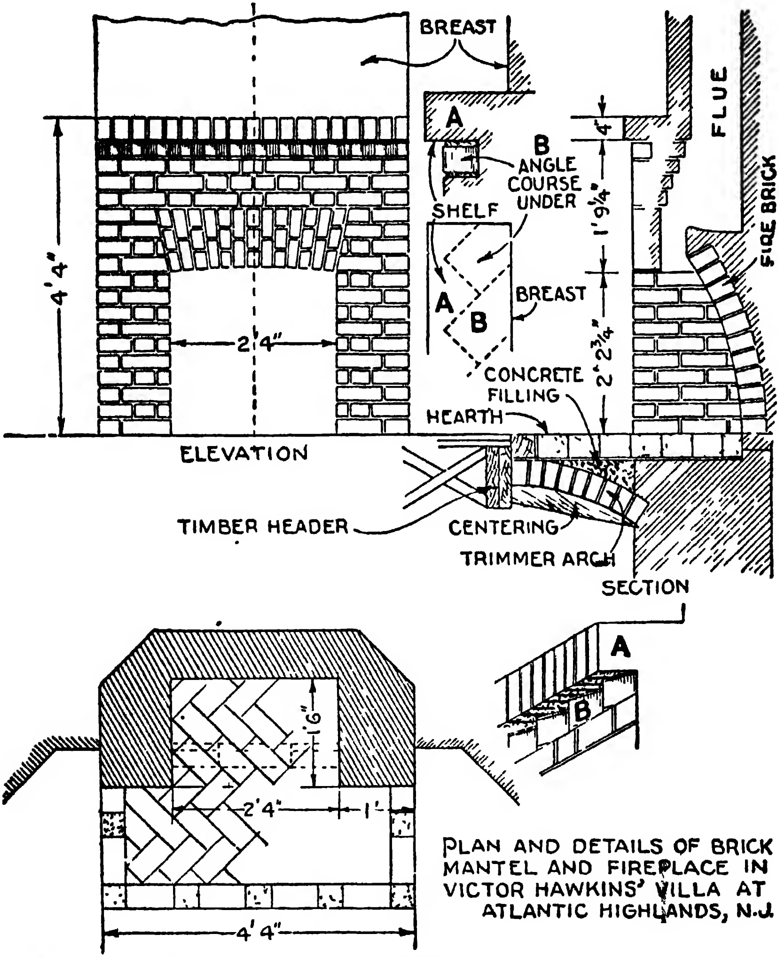
Fireplace Construction.—In the construction of a fireplace, to obtain the greatest efficiency, the heated gases should be made to travel horizontally as far as possible over the brick radiating surface before passing into the flue. The back is therefore made to slope outward as much as possible, the slope starting at about the top of the fire and throat placed well forward. In plan, the sides of the fireplace should have considerable splay so that they will radiate heat into the room. A damper will help to regulate the draft. The general construction of a fireplace and hearth is shown in figs. 1 to 4.

As here shown, the front and back hearth is generally laid of the same brick as the mantel, either flat or on edge. Sometimes the back hearth is of fire brick. The portion projecting into the room rests upon a trimmer arch thrown from the fireplace to the header joist, the filling between the trimmer and the hearth being either lean concrete or mortar.

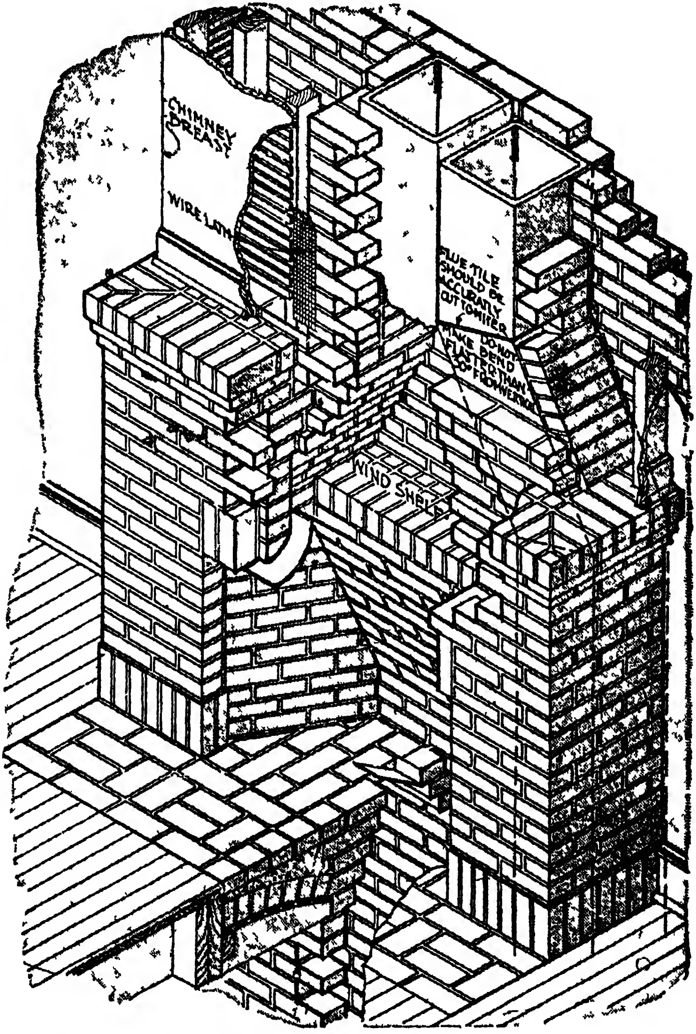
An ash dump, emptying into an ash pit with a clean-out door at the bottom, is of great convenience. These also may be formed of the same brick as used for the mantel. Fire brick are sometimes used. The back should be perpendicular for two or three courses, sloping outwards from this point.

All fireplaces should be built in accordance with the few simple essentials of correct design if satisfactory performance is to be realized. They should be of a size best suited to the room in which they are used, and from the standpoint of appearance and operation, they should fill the necessary requirements. If too small, they may function properly but will not generate a sufficient amount of heat. If on the other hand, they are too large

a fire that would fill the combustion chamber would be entirely too hot for the room and would make the room uncomfortable and also result in a waste of fuel.



FIGS. 1 to 4.—Showing details of fireplace and hearth.



ig 5 —Sectional view showing construction of fireplace

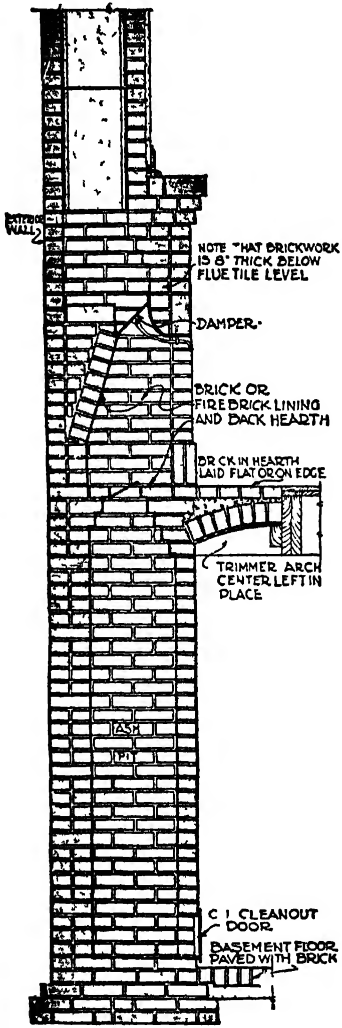
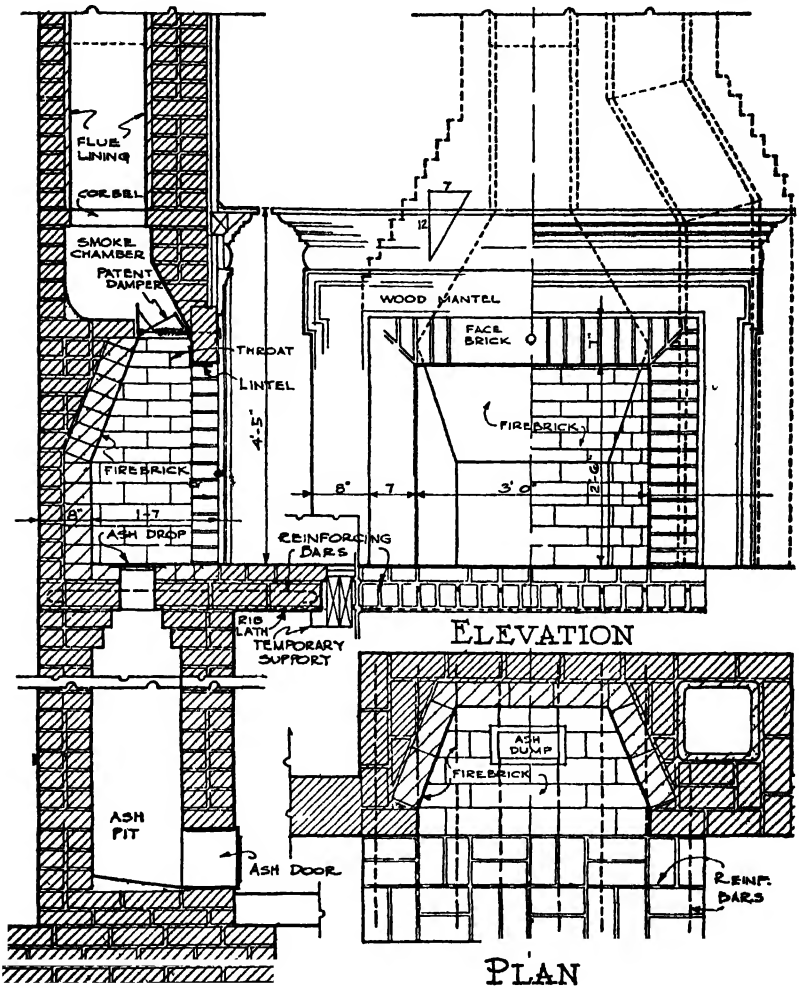


Fig 6 —End section of fireplace shown in fig 5.



SECTION

FIGS 7 to 10 —Showing working drawing of typical fireplace. The elevation and section view gives the dimension of the fireplace opening, the size of flue, and the method of laying up the brickwork. The plan and lower sectional views give the dimensions of the hearth and the foundation footings.

Location of the Fireplace.—The location of the chimney determines the location of the fireplace and is too often governed by structural consideration only. Since a fireplace suggests a fireside group and a reasonable degree of seclusion, it should not be located near doors and passageways in a room, but should be located in so far as possible, away from interior and exterior noises and disturbances.

A fireplace is ordinarily considered appropriate to a *living room*, dining room and bedroom They have also found an increasing favor in basement rooms, porches and out of doors, also in public dining places, offices, etc The fireplace besides their ornamental qualities provide both comfort and an air of informality for the occupant

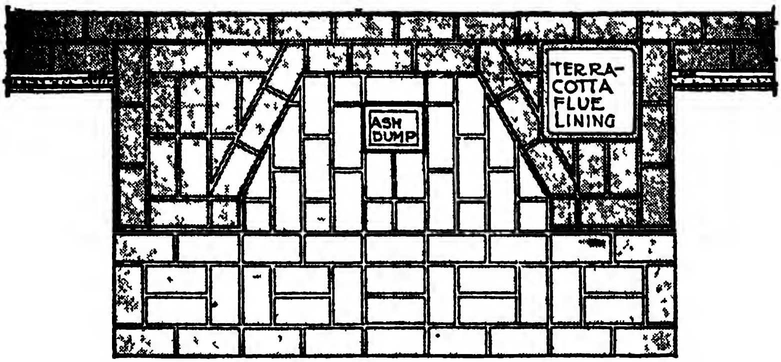


FIG 11 —Plan of fireplace shown in fig 5

Fireplace Foundations.—Due to the mass and consequent weight of the masonry to be supported, a foundation covering an area sufficient to carry the load of the fireplace and the chimney should be constructed. Where the chimney be located so as to be affected by frost, the chimney foundation should be extended to below the frost line. In building the foundation,

the full size of the fireplace makes it possible to construct an open ashpit and other necessary flues on the same foundation.

The footings for chimney stacks may be made of brick or concrete, but in either case the footings should be reinforced with steel rods and designed so as to transmit the load over an area that will not exceed the normal safe bearing capacity of the soil.

Fireplace Dimensions.—Within certain limits the size of the fireplace should be proportioned to suit the size of the room into which it is built. In colonial days when cordwood was plentiful, fireplaces seven feet wide and 5 feet in height were common, especially when used with kitchens for cooking. These however, required large amounts of fuel and were on account of faulty construction often smoky.

The fireplace proper consists of an opening, a throat, and a smoke chamber and flue all of which must be dimensioned in proper relation to each other. A fireplace with too large an opening for its flue is apt to smoke and an incorrectly constructed throat or smoke chamber may make even a properly proportioned fireplace and chimney smoke.

With reference to the foregoing, two qualifying factors determining the size of the fireplace should be kept in mind.

They are:

1. That a fireplace opening in an ordinary size house should seldom be made over 30 inches in height, regardless of the size of the room.

2. That except in the smallest of rooms the width of the fireplace should be a little greater than its height.

Where cordwood (4 feet in length) be cut in half, a 30 inch in width is desirable for a fireplace, but where coal is used as fuel, the opening may be narrower. Thirty inches is a practical

height for the convenient tending of a fire where the total width is less than 6 feet. The higher the opening, the greater the chance of a smoky fireplace.

Another point to be borne in mind is that the wider the opening the greater should be the depth. A shallow opening throws out relatively more heat than a deep one of the same width but accomodates smaller pieces of wood; thus it becomes a question of preference between a greater depth which permits the use of large logs that burn longer and a shallower depth which takes smaller size wood but throws out more heat.

In small fireplaces, a depth of 12 inches will permit good draft if the throat be properly constructed, but a minimum depth of 16 to 18 inches is advised to lessen the danger of brands falling out on the floor.

The ordinary fireplace is constructed generally as illustrated in figs. 12 to 15. In construction of a fireplace the following essentials should be attained. They are:

1. That the flue have the proper area.

2. That the throat be correctly designed and have a suitable damper.

3. That the chimney be high enough for good draft.

4. That the shape of the fireplace be such as to direct the maximum amount of radiated heat into the room.

5. That a properly constructed smoke chamber be provided.

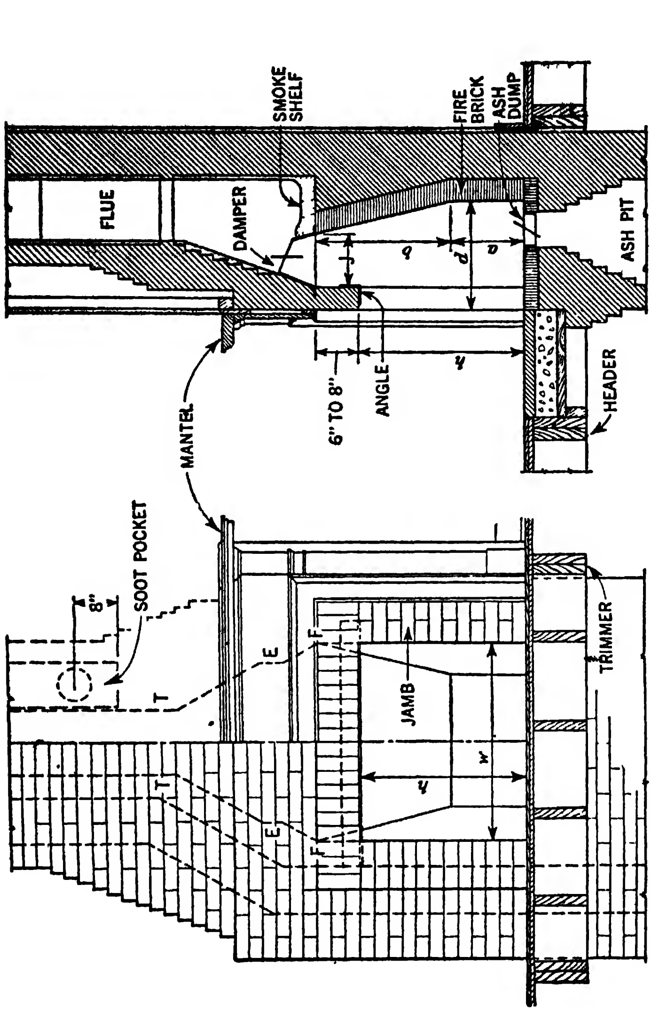
Table I shows the correct dimensions for fireplaces of various widths and heights suitable for the rooms of residences.

Table I.—Showing recommended dimensions for finished fireplaces

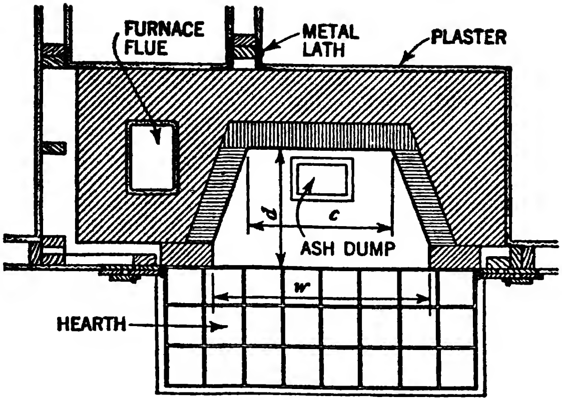
(Letters at heads of columns refer to figs. 12 to 14.).

Opening		Depth, *d*	Minimum back (horizontal) *c*	Vertical back wall, *a*	Inclined back wall, *b*	Outside dimensions of standard rectangular flue lining	Inside diameter of standard round flue lining
Width, *w*	Height, *h*						
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
24	24	16–18	14	14	16	8½ by 8½	10
28	24	16–18	14	14	16	8½ by 8½	10
24	28	16–18	14	14	20	8½ by 8½	10
30	28	16–18	16	14	20	8½ by 13	10
36	28	16–18	22	14	20	8½ by 13	12
42	28	16–18	28	14	20	8½ by 18	12
36	32	18–20	20	14	24	8½ by 18	12
42	32	18–20	26	14	24	13 by 13	12
48	32	18–20	32	14	24	13 by 13	15
42	36	18–20	26	14	28	13 by 13	15
48	36	18–20	32	14	28	13 by 18	15
54	36	18–20	38	14	28	13 by 18	15
60	36	18–20	44	14	28	13 by 18	15
42	40	20–22	24	17	29	13 by 13	15
48	40	20–22	30	17	29	13 by 18	15
54	40	20–22	36	17	29	13 by 18	15
60	40	20–22	42	17	29	18 by 18	18
66	40	20–22	48	17	29	18 by 18	18
72	40	22–28	51	17	29	18 by 18	18

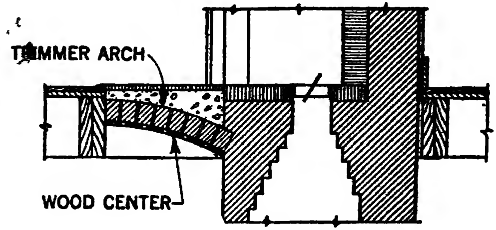
Dampers.—If a damper be installed, the width of the opening **J.** fig. 13, will depend on the width of the damper frame, the size of which is fixed by the width and depth of the fireplace and the slope of the back wall. The width of throat proper is determined by the opening of the hinged damper cover. The full damper opening should never be less than the flue area.



FIGS. 12 and 13.—Showing construction details for typical fireplace. Dimensions indicated by letters for various size fireplaces are given in Table I page 354-7.



PLAN



SECTION
(Showing Alternate Hearth)

FIGS. 14 and 15.—Showing plan and alternate section of fireplace shown in figs. 12 and 13. Dimension indicated by letters for various size fireplaces are given in Table I. The sides should be vertical up to the throat or damper opening **F-F**, fig. 12. The throat should be 6 to 8 inches or more above the bottom of the lintel and have an area not less than that of the flue and a length equal to the width of the fireplace opening. Starting 5 inches above the throat **E-E**, the sides should be drawn in at **T-T** to equal the flue area. The smoke shelf is made by setting the brickwork back at the top of the throat to the line of the flue wall for the full length of the throat. Its depth may vary from 6 to 12 inches or more depending upon the depth **d** of the fireplace. The smoke chamber is the space extending from the top of the throat **E-E** up to the bottom of the flue proper **T-T** and between the side walls. The walls should be drawn inward 30 degrees to the vertical after the top of the throat **E-E** is passed and smoothed with cement mortar not less than one half inch thick.

A well designed and properly installed damper is regarded as essential, particularly in cold climates. When no damper is used the throat opening **J**, should be 4 inches for fireplaces not exceeding 4 feet in height.

There are several good types of dampers on the market which also form a lintel to carry the brickwork across the opening. Their use is strongly recommended. Where not used, a separate damper should be placed and the brickwork carried on a steel lintel, except where the arched opening is preferred.

Placing the throat well forward has another advantage, namely that of forming a smoke shelf at the damper level. This shelf aids in stopping the down drafts which will almost invariably occur if the back of the fireplace be made to rise vertically in the same plane as the back of the flue.

The opening above the smoke shelf should be "*gathered*" or *contracted* to the size of the flue by *corbelling*, this being done with the least height practicable. Up to the level of the clay flue lining, the brickwork should not be less than 8 inches thick, because the space immediately above the damper is the hottest place of the chimney.

Flues and Flue Linings.—By definition, the flue is that enclosed passageway for establishing and directing smoke and gases through the chimney to the outside air. Although chimneys may be built without flue linings, it is necessary to make the walls at least 8 inches thick, using firebrick for the inner course. It is generally conceded in modern building practice that flues should be lined with fire clay flue lining and many *city building Codes* require this.

Fireplace linings should be constructed either of firebrick or a reasonably high refractory shale brick, but they should never be laid up of ordinary common brick. Unless a rough and somewhat rustic appearing lining is desired, the brick for this purpose should be selected so that they will be uniform in size and free from such imperfections as warping and broken edges.

The mortar joints of fireplace linings should be tooled or slightly concave or should be struck and pointed flush. Mortar joints should seldom be more than one-half inch wide. All spaces between the lining and the enclosing brick masonry of chimney stacks should be filled in with brick and mortar as the lining is built.

There is a direct relationship between the area of the fireplace opening and that of the lined flue. This relationship may be stated as follows: *The area of lined flues should be a* **twelfth** *or more of the fireplace opening, provided the chimney be at least* 22 *ft. in height, measured from the hearth. If the flue be shorter than* 22 *ft. or if it be unlined, its area should be made a* **tenth** *or more of the fireplace opening.*

Thus, for example, if the fireplace opening be 36 x 28 inches, the area of the fireplace opening will be 1,008 square inches. and the lined flue area should be 1,008/12 or 84 sqaure inches.

In the example under consideration a rectangular flue 8½ x13 inches outside dimensions, or a round flue with a 12 inch inside diameter might be used, as these are the nearest commercial sizes of lining as shown in table I. It should be pointed out that it is seldom possible to obtain a flue lining having exactly the required area, but the inside area should never be less than that prescribed in the foregoing.

Commercial flue linings are made either round, square or oblong. A table giving dimensions for rectangular and round flue linings is given on page 1,890-344. While the round flue is the most efficient type to use in residence construction, the square or nearly square flue, with rounded corners is generally used on account of the greater ease with which it can be built in the chimney stack. These flue linings are made in sizes that permit them to be built in without much cutting of brick.

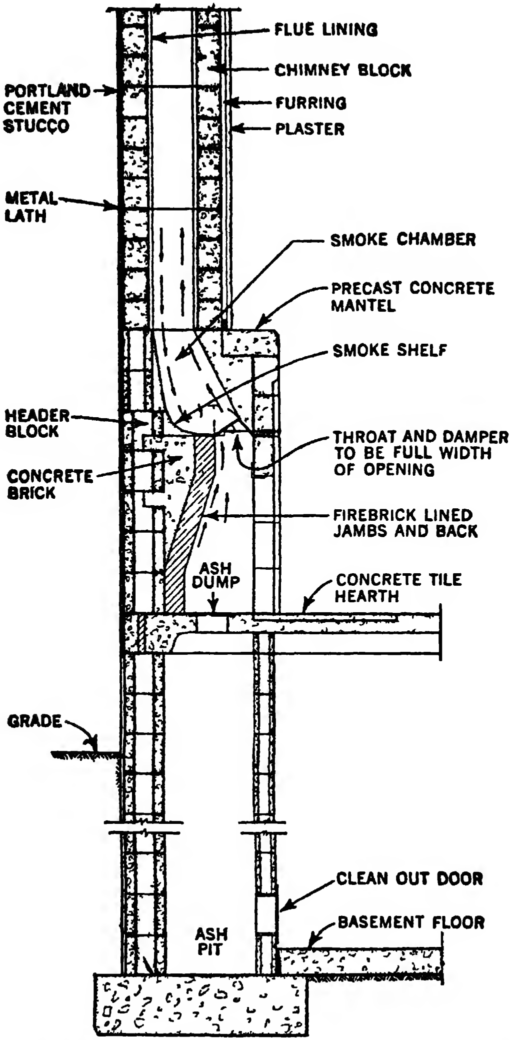


FIG. 15A.—Typical section through fireplace and ash pit using concrete masonry units.

Because the gases in a flue circulate in the center and do not fill the square corners, square or rectangular shaped flues should have a little more area in their cross section than round flues.

If two flues occur in the same chimney stack, it is permissible to place them side by side if the joints be staggered. Wherever there is room, however, four inches of brick should be used between all flue linings.

Every fireplace should have a *separate flue* carried to the top of the chimney, with no other connection. Smoke may easily be carried by down drafts through connections and openings which are not in use. Not more than two flues should be in the same chimney space.

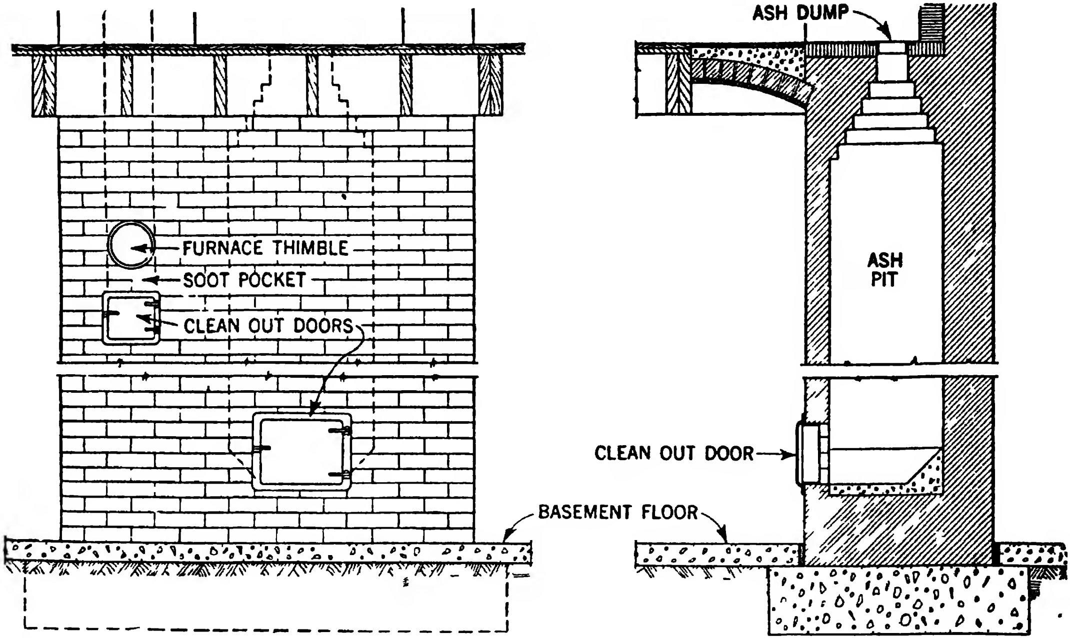
Fireplace Hearth.—The hearth should be about flush with the floor, for sweepings may then be brushed into the fireplace. Where there is a basement, an ash dump located in the hearth near the back of the fireplace as shown in fig. 17 is convenient. The dump consists generally of a metal frame 5 by 8 inches in size, with a plate, usually pivoted, through which ashes can be dropped into a pit below.

There are several methods of supporting the hearth, but the most common one is by means of a trimmer arch, the construction of which is shown in fig. 17. Hearths should project at least 16 inches from the chimney breast and should be of brick, stone or reinforced concrete not less than 4 inches thick.

When bricks are used, they may be laid flatwise to whatever pattern desired. These bricks are bedded in mortar spread on supporting arch or concrete slab, and joints between them should be filled with a mortar grout.

The length of the hearth should not be less than the width of the fireplace opening plus 16 inches. Wooden centering under the trimmer arches may be removed after the mortar has set, though it is more frequently left in place. Fig. 17 shows a recommended method of floor framing around the fireplace.

The Smoke Chamber.—The smoke chamber leading from the fireplace to the flue should always be made full width at the



FIGS 16 and 17 —Showing construction for ash pit in residence with full height basement The ash pit should be of tight masonry and should be provided with a tightly fitted iron clean out door and frame about 10 by 12 inches in size A clean-out for the furnace flue as shown is sometimes provided

opening and sides should be sloped up from the smoke shaft to the flue at an angle of not less than 45 degrees and should be reasonably smooth and free of rough projections.

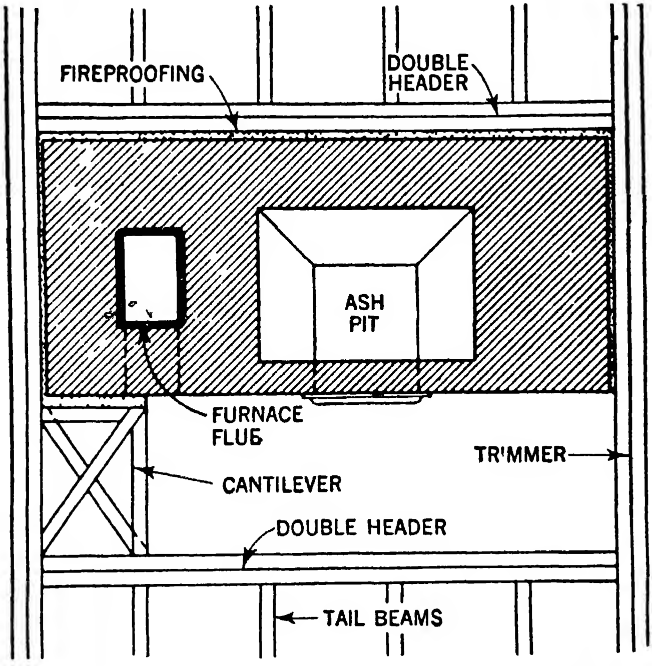


FIG. 18.—Showing a recommended method of floor framing around a fireplace. Where a header is more than 4 feet in length it should be doubled as indicated. Headers supporting more than four tail beams should have ends supported in metal joist hangers. The framing may be placed one half inch from the chimney because the masonry is 8 inches thick.

The lintel at the top of the fireplace should be placed 4 inches or more below the top line of the back or the under side of the throat opening regardless of whether a simple damper cover or cast iron throat is used.

Although fireplaces constructed with only 4 inches of brickwork between the mantel face and the throat frequently prove satisfactory, it is better to make this brickwork at least 8 inches thick up to the level of the throat. From this point the fireplace may be readily corbelled back and the thickness of the chimney breast reduced. Although chimneys are frequently built with only 4 inches of brickwork on the outside of the flue lining, an 8 inch thickness is recommended, especially in the colder northern sections of the country.

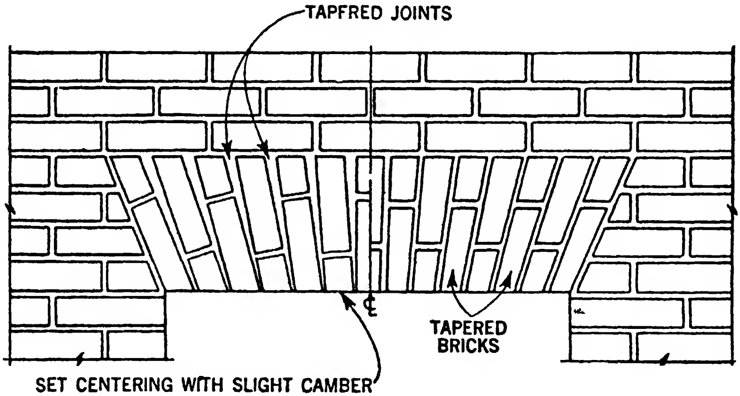


FIG 19—Showing typical jack arch used in brick fireplace The illustration shows the arch on the left laid up with tapered mortar joints while the arch on the right is laid up with tapered brick Either method may be used to obtain a satisfactory arch

The flue should always be taken off from the smoke chamber directly over the center of the fireplace opening, even though the flue is carried over at an angle to the side of the chimney stack a few feet where it leaves the smoke chamber. The angle of this slope should never be made more than 45 degrees to the horizontal. Where an angle run is jointed to a straight run, the joint should be mitered by cutting the sides of both pieces of flue lining so that the sectional area will be the same throughout the length of the flue

Heatilators and Other Modified Fireplaces

There are several types of modified fireplaces on the market manufactured to suit individual preferences. Generally a modified fireplace consists of a ready built unit usually installed in the brickwork as shown in figs. 20 to 28.

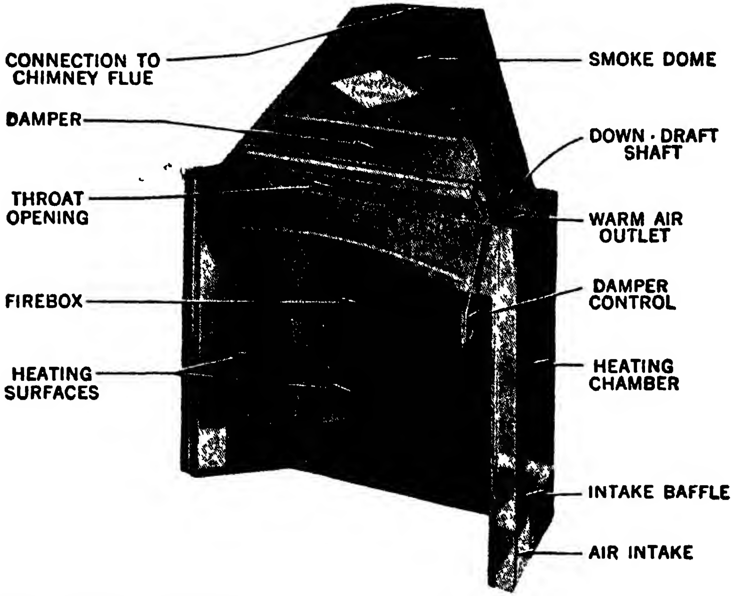
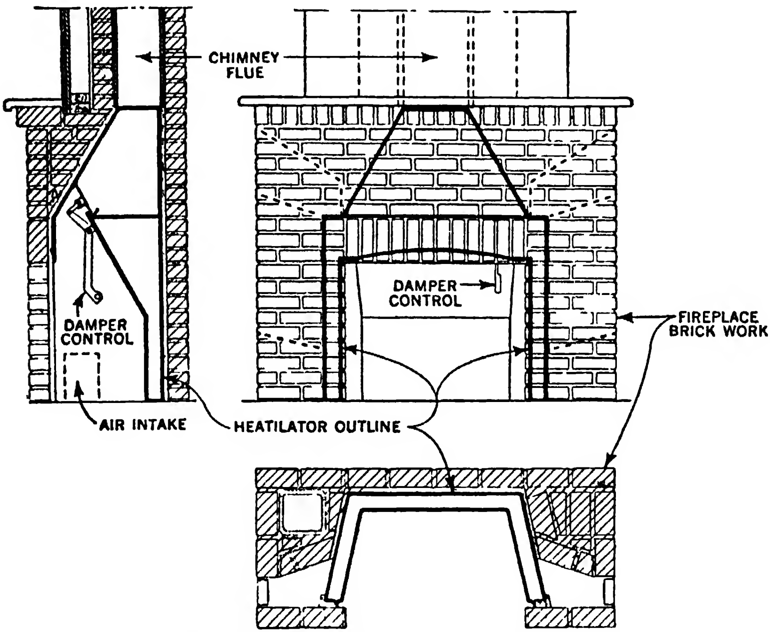


FIG. 20.—Showing a prefabricated modified fireplace of the *heatilator* type.

These units are built of heavy metal or boiler plate steel and designed to be set into place and concealed by the usual brickwork, or other construction so that no practical change in the fireplace mantel design is required by their use.

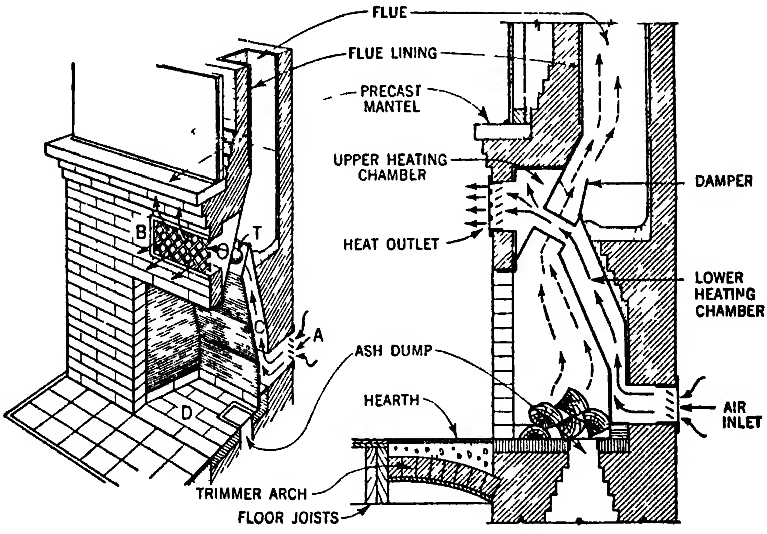
One claimed advantage for modified fireplace units is that the correctly designed and proportined fire box manufactured with throat, damper, smoke shelf and chamber, provides a form for. the masonry, thus reducing the risk of failure and assuring a smokeless fireplace.



FIGS 21 to 23 —Showing method of brick work construction in a *heatilator* equipped fireplace

There is, however, no excuse for using incorrect proportions; and the desirability of using a foolproof form, as provided by the modified unit, merely to obtain good proportions. Each fireplace should be designed to suit individual requirements and if correct dimensions are adhered to, a satisfactory fireplace will be obtained.

Prior to selecting and erecting a fireplace, several suitable designs should be considered and a careful estimate of the cost should be made; and it should also be borne in mind that even though the unit of a modified fireplace is well designed, it will not operate properly if the chimney be inadequate. Therefore, it follows, that for satisfactory operation, the chimney must be made in accordance with the rules for correct construction to give satisfactory operation with the modified unit as well as with the ordinary fireplace.



FIGS 24 and 25 —Typical modified fireplace In this modified fireplace air enters the inlet **A**, from outside and is heated as it rises by natural circulation through the back chamber **C**, and the tubes **T** being discharged into the room from the register **B**. Air for supporting combustion is drawn into the fire at **D**, and passes between the tubes up the flue. A damper is also provided to close the air inlet.

Manufacturers of modified units also claim that labor and materials saved tend to offset the purchase price of the unit and that the saving in fuel tends to offset the increase in first cost.

A minimum life of 20 years is usually claimed for the type and thickness of metal commonly used in these units.

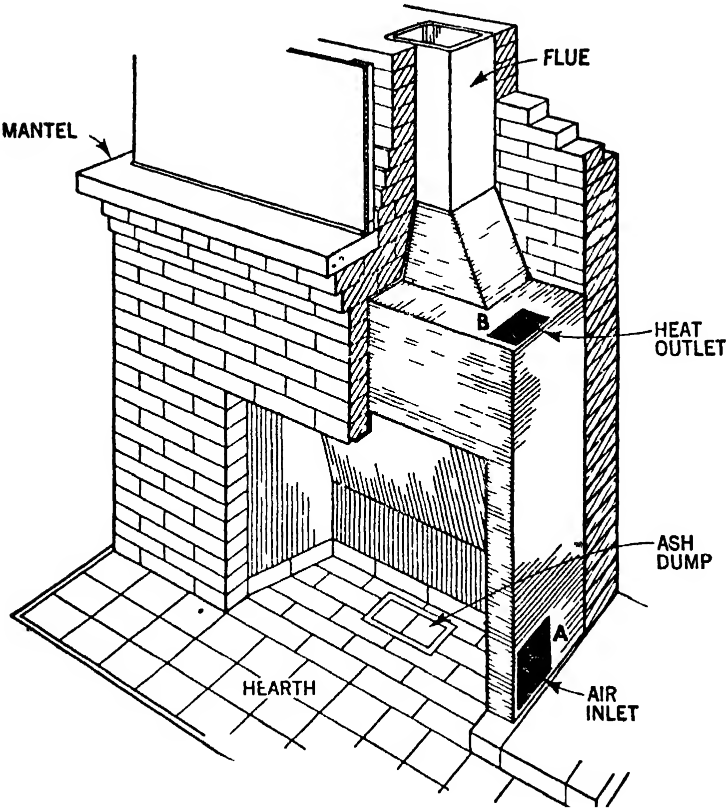
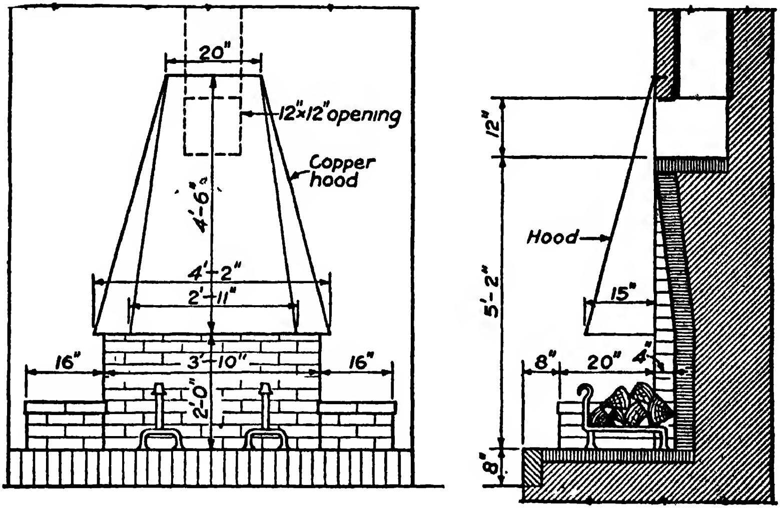


FIG 26 —Typical modified fireplace In this fireplace the air is not drawn in directly from the outdoors but through the inlet D from the room that is being heated The air is heated by contact with the metal sides and back of the fireplace rises by natural circulation and is discharged back into the room from the outlet B or to another room on the same floor or in the second story The inlets and outlets are connected to registers which may be located at the front of the fireplace The registers may be located on the ends of the fireplace or on the wall of an adjacent room

As previously observed a fireplace should be planned as an integral part of the room in which it is located, and not as a separate unit. Therefore, the size and shape of the room, location and space available for the fireplace, position of doors and windows and the general architectural treatment will determine the proportions of the mantel and the size of the fireplace opening.

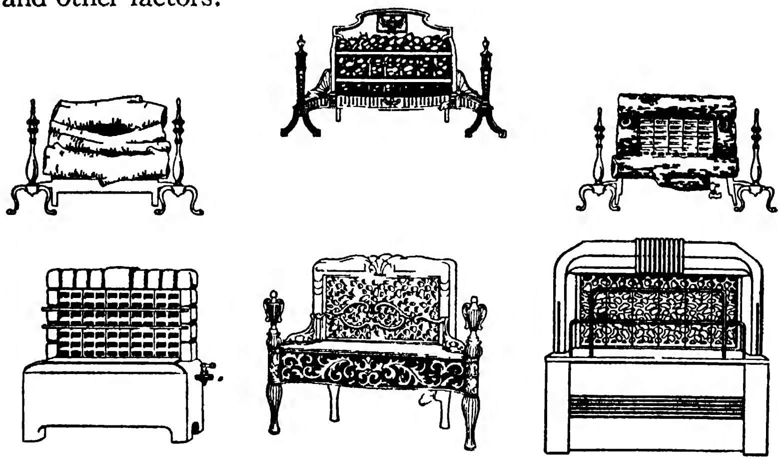


FIGS 27 and 28 —Showing a modified fireplace equipped with a copper hood suitable for smaller sized cord wood. If properly designed and erected a fireplace of this type generates considerable heat after the hood gets hot The wall should be of fire-resistant masonry

In the past it has been the general practice to set heating capacity in B.t.u. output ratings as guide in selecting the proper size unit. Now scientific laboratory tests indicate that such data is generally misleading, as no two fireplaces are built or operated under identical conditions. Therefore, claims for an increased efficiency for a modified fireplace should, at best, be understood merely as constituting an improvement over the ordinary fireplace and not over stoves or central heating plants.

Gas Burning Fireplace Heaters.—In locations where natural gas is plentiful and in cities where suitable cordwood is difficult to obtain, gas fired space heaters are often used.

These are prefabricated units, having input ratings in B t.u. per hour, and are built by various gas appliance manufaturers. Fireplaces of this type burning gas with a flickering flame, are frequently used as an auxiliary to the main heating plant. Some types have imitation logs of metal perforated for gas jets. Any ordinary fireplace may have a gas burning unit installed in it, the size which generally depends upon the size of the room and other factors.



FIGS 29 to 34 Illustrating design features of various size gas burning fireplace heaters The great number of styles available makes it possible to select a heater suitable to the decorative period of room or material and type of fireplace

Prior to purchasing a heater of this type it will be necessary to supply the manufacturer with such information as height width and depth of fireplace opening kind of gas used information about flue and damper conditions decorative period of room or material together with general color of the fireplace Certain heaters of this type are equipped with a compartment for water that by evaporation creates oxygen and humidifies the atmosphere in the room

Installion.—Gas burning fireplace heaters are usually furnished with a nameplate which furnish such necessary data as: *Input rating in B.t.u. per hour, whether the unit be designed for vented or unvented operation, type of gas burned, whether natural, manufactured, butane or propane, etc.*

All gas burning fireplaces designated for vented operation must have a suitable vent connection between the appliance draft diverter outlet and the chimney flue. No attempt should be made to install any gas burning space heater in an *artificial fireplace* which is intended for decorative purposes only, but they may be installed in fire resistive fireplaces which have vent openings to the chimney.

If the gas heater be designed for unvented operation, installation is relatively simple since all there is required is to place the heater in its proper position in the fireplace and make the proper gas connection between the heater and the gas line. Gas should always be *turned off* at meter before making such connections. *Gas line to fireplace should not be less than 3/8 inch iron pipe* or equivalent size tubing. For gas heaters of over 20,000 B.t.u./hr. input, gas line must be of the *same size* as that of the connection on heater. Heaters should be positioned so that front end of back-wall does not project beyond front edge of fireplace opening.

If fireplace be equipped with damper, this should be adjusted to leave approximately one inch opening along the entire length. If fireplace does not have a damper, it must be blocked off with a sheet metal baffle to leave an opening therein equivalent in area to a 5 inch diameter circle. All that remains after the foregoing instructions have been fulfilled is to adjust the gas burner according to the specific instructions accompanying the heater.

Certain unvented type gas fired heaters are designated for use in *incombustible, fire resistive fireplaces only*, and when such designation appears on the nameplate it must be understood that installation is considered fireproof only when made in a fireproof fireplace.

Other Miscellaneous Gas Fired Space Heaters.— Other unvented heaters (radiant and non-radiant) such as small circulators and bathroom heaters represent still another group. Unvented circulators are commonly installed in fireplaces, just as are space heaters. Actually this makes the safest installation. A great number, however, are installed contrary to recommended practice. Therefore, extreme care in installing is urged. Since no flue connection is used, only connection to proper size gas line is necessary. Be very careful in positioning of these heaters. They should not be closer than 6 ins. to any wall.

They should not be located beneath or in front of curtains or drapes. Bathroom heaters should *not* be located under *towel racks* or in *hazardous places*. Remember that the use of unvented heaters in **sleeping rooms** is prohibited. Strictly speaking, they should only be used as auxiliary heaters in a home. They should not be used in tourist cabins, motels, etc. Stores, factories, service stations, etc. offer much more latitude in the use of unvented heaters. However, even in commercial installations, unvented heaters should never be used in rooms not having continuous air change (outside ventilating air) equivalent to six air changes or more per hour.

All this may seem to overstress the correct use of unvented heaters, but it at least points to the source of most troubles with gas space heaters. A common objection to the unvented heater is the odor from unit improperly adjusted. Another is excessive moisture from flue products, causing sweating on walls and windows, as well as mildew, rot, rust, warping of woodwork or floors, peeling of paint and wall paper. It must be remembered that if the products of gas combustion are not removed from a room, then these objectionable conditions will continue to annoy and dissatisfy the user.

Gas Piping—The installation of all gas piping is customarily governed by local ordinance and it is urged that the installation of gas fired heaters be installed in strict accordance with such regulations, whether City or State. The following good piping practice recommendations should be followed in each installation:

1. In no case shall size of gas supply pipe to appliance be less than inlet connection of the appliance being installed.

2. All material used on the job shall be new, standard weight wrought-iron or steel pipe.

3. Pipe ends shall be thoroughly reamed after threading and before making up.

4. When necessary to connect 2 sizes of pipe, reducing coupling shall be used.

5. All house piping shall be securely fastened to floor joists or sills, with galvanized pipe straps or pipe hooks.

6. All branch outlet pipes shall be taken off top or sides of horizontal lines. Not from bottom. Crosses shall not be made on horizontal lines.

7. All house piping shall be graded to a drip located in an accessible place. Where possible, house piping should be drained away from meter and drip installed at far end of main supply line. As an alternative, install drip at meter, but grade pipe to it. Drip pipe shall be at least 6 ins. long and be of same size as that to which it is attached. It is important that drip pipes be readily accessible at all times, never used to attach fixtures or appliances.

8. When it is necessary ti-cross through wood joists or beams in piping, never notch deeper than one-fifth (1/5) the depth of such timbers, nor farther out than 24 ins. from wall or other support.
9. All gas installations shall be provided with a lever type stop cock installed in supply line between meter and union of appliance.
10. All piping installed in the ground or beneath houses where exposed to sudden temperature changes and freezing shall be suitably insulated for protection.

Making Gas Connection—Once flue connection to appliance has been completed, the next step is to attach the appliance to the gas line. Essentially this means connecting appliance to meter or to gas line stemming from meter. Gas meter should be checked in advance to insure sufficient capacity for the installation.

For gas fired space heaters having less than 45,000 B.t.u./hr. input on natural, mixed or LP (liquefied petroleum) gases, a ½ in. pipe is usually satisfactory for supply. For heaters having greater input, ¾ in. pipe is recommended. Capacity required for other equipment installed on the same line must also be considered.

When controls are installed in gas line ahead of appliance, manufacturer's specific instructions and recommendations should be followed.

Checking Piping for Leaks—When piping has been completed and heater has been coupled to gas line, test all joints for leaks. Never take chances by checking gas lines with a *lighted match* or *candle*. Do it the safe way with soap and water. Merely apply a heavy solution of soap suds to joints. Tell-tale bubbles will promptly appear to point out the leaks.

If leaks be discovered in the checkup, mark joints needing attention. After completing test, go back over the line tightening joints till leak-proof, but not until after *gas supply* in line has been *shut off*. Above all, never attempt repairs on a gas line while there is a lighted flame and under no circumstances attempt to light and operate heater with leaks in gas line.

Installation Rules.—The following rules apply to the installation of gas burning fireplace and other gas fired space heaters:

1. Check nameplate on heater. Be sure it is designed for the gas available.

2. Follow installation and adjusting instructions (Packed with heater).

3. Adjust heater to correct input rating by checking gas meter. (for LP-Gas heaters, by setting line pressure at appliance to 11 inches).

4. When all piping has been completed to heater, check entire line for leaks. (Use soap and water solution in testing —never a lighted match).

5. See that there is sufficient air for proper combustion. See that there is adequate air supply for proper venting.

6. Be sure that venting of heater is correct. (Refer to instructions packed with heater).

7. Check to see that chimney is clean, unbroken and in good condition generally before connecting vent to it.

8. Thoroughly read all instructions on operating procedure of heater and controls. Keep all instructions in a safe place that they may be readily available for further reference.

Smoky Fireplaces.—When a fireplace smokes, it should be examined to make certain that the essential requirements of construction as outlined in this chapter has been fulfilled. If the chimney be not stopped up with fallen brick and the mortar joints be not too loose, note whether nearby trees or tall structures cause eddies down the flue.

To determine whether the fireplace opening is in correct proportion to the flue area, hold a piece of sheet metal across the top of the fireplace opening and then gradually lower it, making the opening smaller until smoke does not come into the room. Mark at the lower edge of the metal on the sides of the fireplace.

The opening may then be reduced by building in a metal shield or hood across the top of the fireplace so that its lower edge is at the marks made during the test. The trouble of smoky fireplaces can also usually be remedied by increasing the height of the flue.

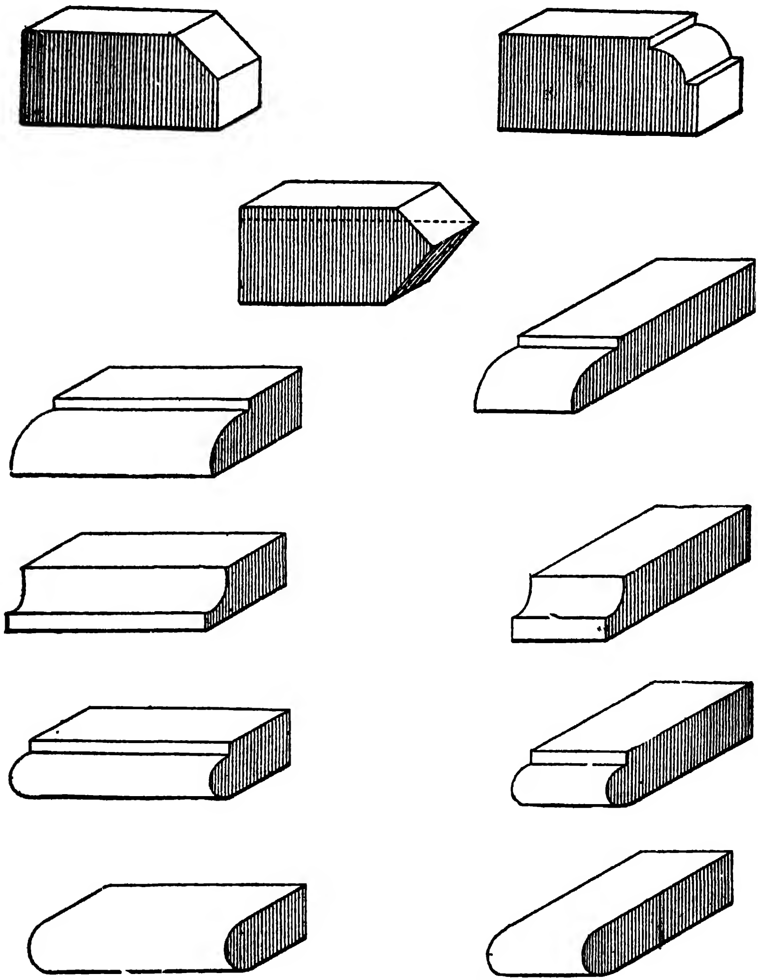
CHAPTER 79

Ornamental Brickwork

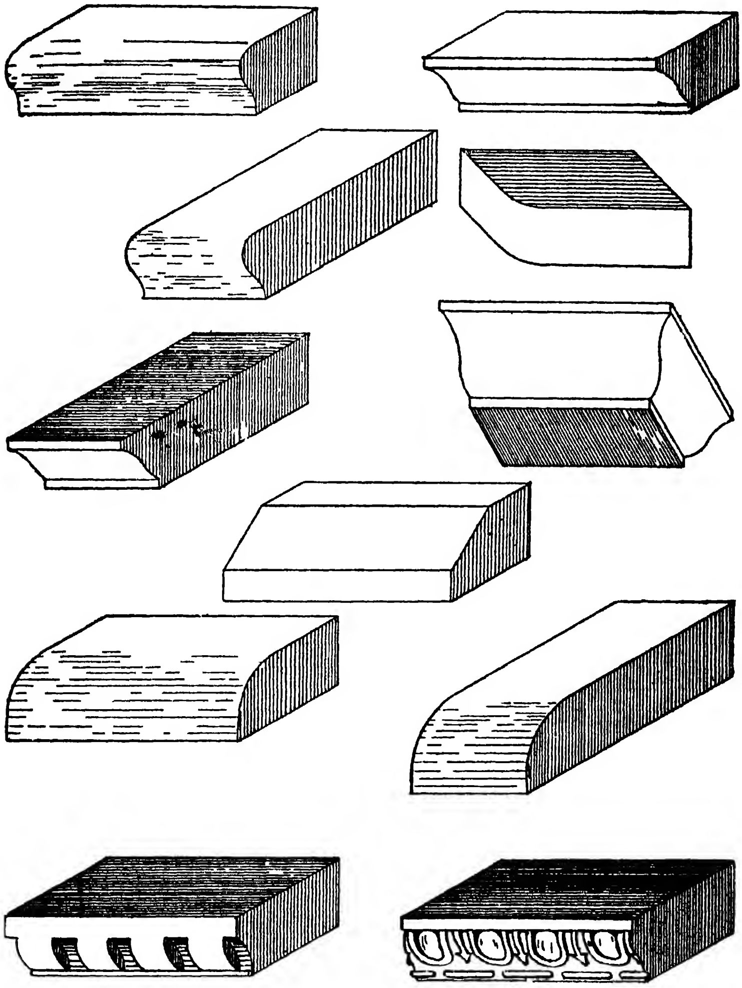
Ornamental Brickwork.—Numerous difficulties are presented to the bricklayer on finished work because of the many designs or panellings, projectings, etc., introduced by architects in their designs, as on front of buildings, cornices, etc. To get these effects, bricks must be laid in a multiplicity of ways resulting in the bricklayer being confused as to how to get the bond to come out right. Hence, mental effort as well as skill in brick laying is required in ornamental brick work. Panelling is largely used, but need not here be considered as it has already been explained in Chapter 70. There is a large field for design in surface ornament by means of brick moulded to special shapes. Moulded brick cornices, belt cornices, and in fact any moulded work of brick is much cheaper than stone.

Laying Brick Mouldings.—It is difficult in this work to get the moulding to run straight and true because nearly all moulded brick become somewhat uneven and distorted in contour from moulding and burning; hence, when they are laid in the wall, the ends that come against each other do not match evenly. The best moulded brick are nearly free from this defect.

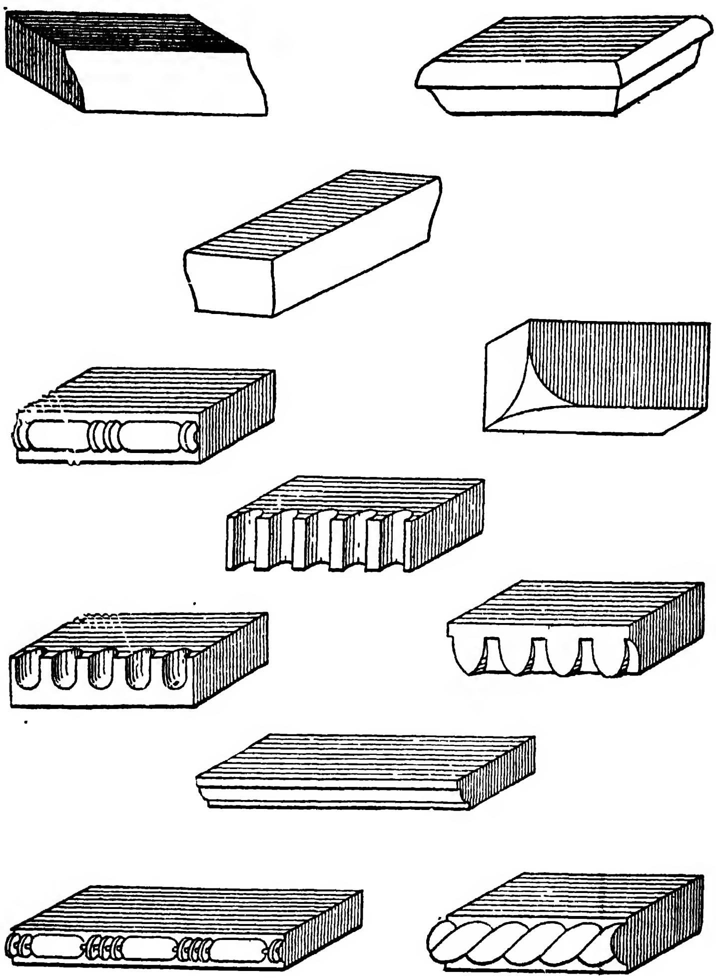
If the brick be carefully averaged when laid, so that the ends will match as nearly as possible and the joints are neatly ruled,



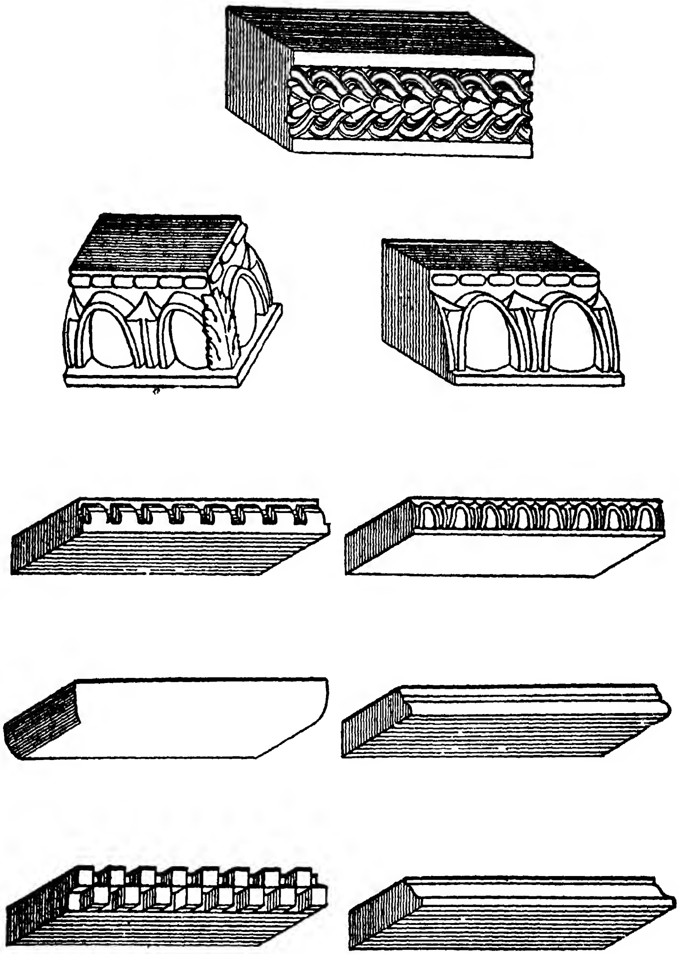
FIGS. 4,445 to 4,455.—Sayre & Fisher ornamental front brick. *Size of brick* 8¼ ×4×2¼ Returns or angle brick made in any of the above moulds



Figs. 4,556 to 4,566 —Various ornamental front brick Size of brick 8¼ ×4×2¼. Returns or angle brick are usually made in any of the above moulds.



FIGS. 4,567 to 4,577.—Various Pompeian size (12×4×1½) ornamental front brick.



Figs. 4,578 to 4,586 —Various 12×5×4 ornamental front brick.

the uneven effect may be largely overcome. The distortion shows less in header brick than in stretcher, because they have less surface to distort.

The projection of the brick in mouldings, belt courses, etc., should be as small as possible to carry out the design in order

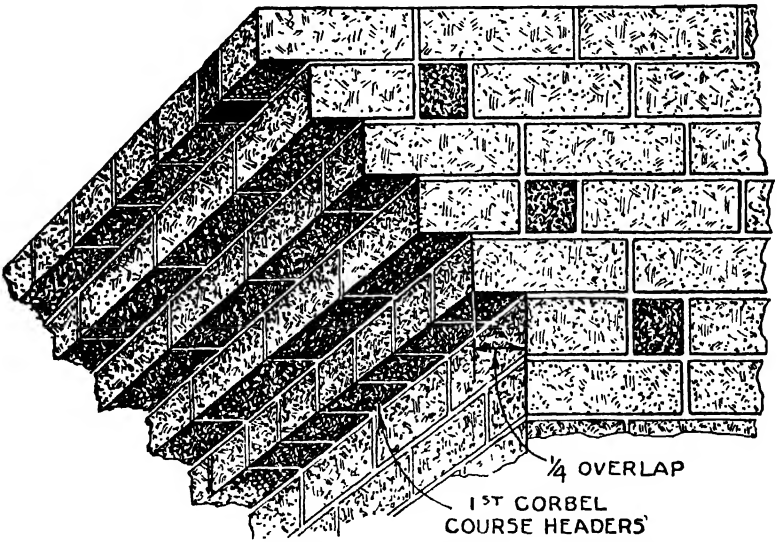


FIG. 4,587.—Brick corbel having first course of headers and 1/4 or maximum overlap.

that the brick may bond back into the wall. If the projection be too great, there is danger of the brick falling out.

Corbeling.—The term corbeling means *the projecting courses of brick designed to carry some load;* it may be to support the gutter that receives the water from the roof or it may be to receive a wall plate, etc.

In corbeling it is very important that the bricks of each projecting course do not extend out or *overlap* more than 2 inches, or half the width of a brick. With this restriction the first projecting course may be a stretcher course. An example of brick corbeling with two inch projections is shown in fig. 4,587.

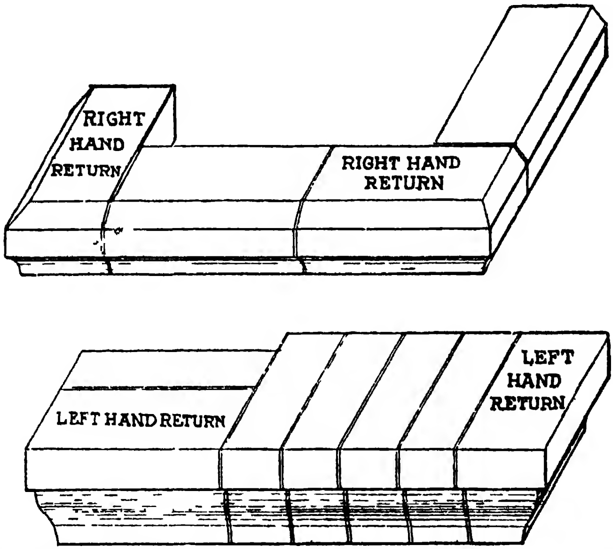


FIG 4,588 and 4,589 —Hydraulic Press Brick Co ornamental external returns *The returns* of a few shapes are made square and give same effect for either corner Most returns are made only right hand or left hand but may be used for either corner as above.

Corbeling should be done gradually, ranging from ¾ to 2 inches in each projecting course. However, no corbeling should extend more than the thickness of the wall, for heavy corbeling has a tendency to throw the wall out of balance and thus we run the risk of having the wall fall.

Corbeling should be well backed up and bonded at each course, and the joints filled flush.

Belt Courses.—The top of all brick belt courses should be laid in beveled brick, so as to give a wash to the top of the

course, as shown in fig. 4,591. The top course should be laid as a stretcher course provided it does not project more than 3 ins. from the face of the wall; this reduces the number of end joints in the brickwork. In belt courses, the brick should

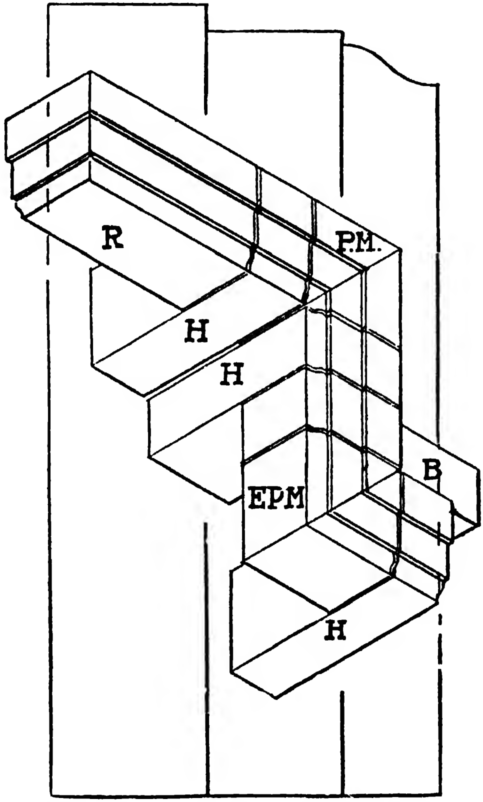


FIG. 4,590 —Hydraulic Press Brick Co ornamental jamb brick with binders—straight line. R, external return, P M, internal panel mitre, H, header, E, P, M, external panel mitre; B, binder.

be laid in cement so that the mortar in the joints will not be washed out. If the top course be a stretcher course, the

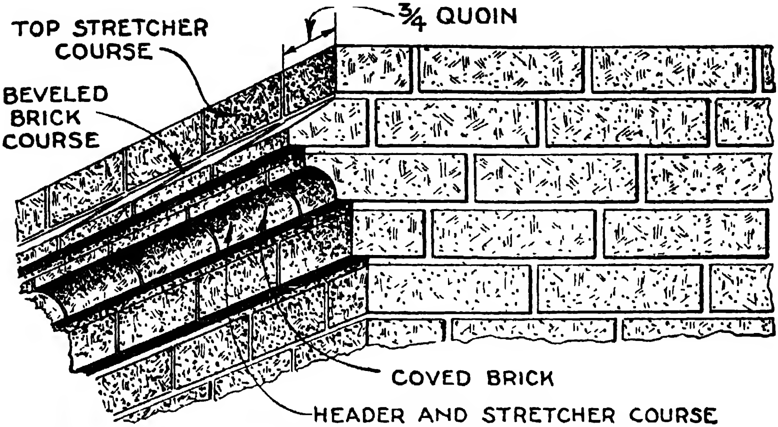


FIG. 4,591 —Example of belt. Courses with beveled brick.

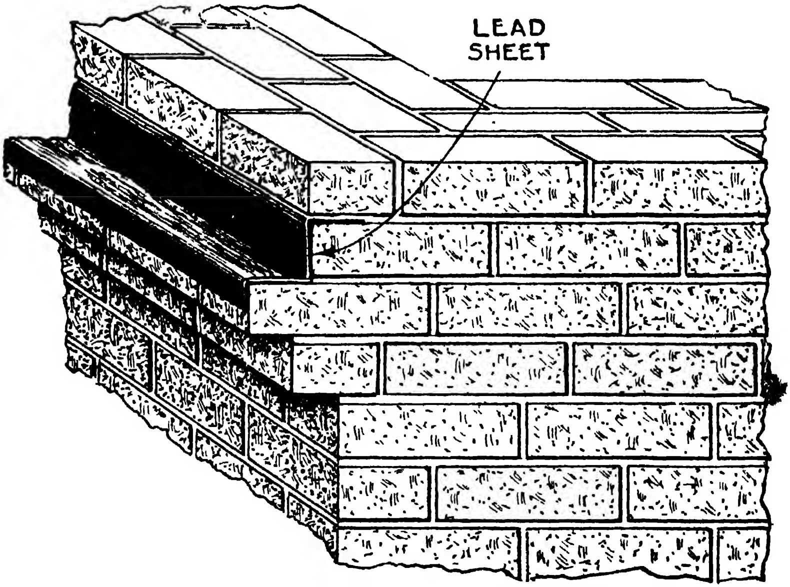


FIG. 4,592.—Belt courses with lead sheet protection where beveled brick are not used for the top course.

course under the beveled brick, or curved brick course should have at least every other brick a header.

When beveled brick are not used, some means of protecting the projecting brick from the wet as the rain will eventually soften the joint and penetrate into the wall. This may be done by means of lead sheets as shown in fig. 4,592.

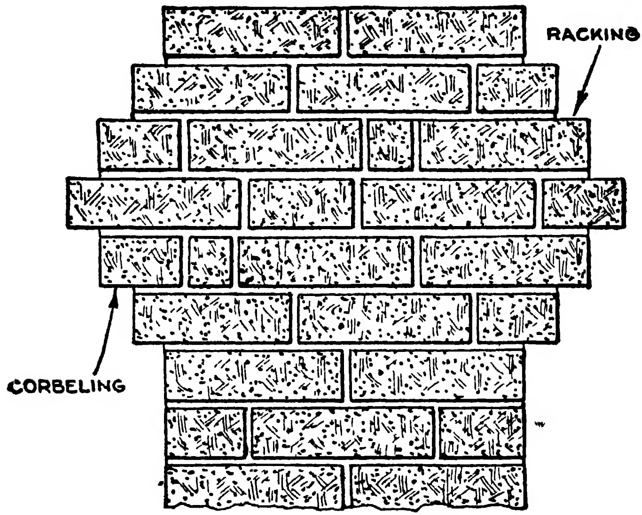


FIG. 4,593.—Conventional chimney capping illustrating both corbeling and racking.

Racking.—This is the reverse of corbeling and may be defined as *the method of building the end of the wall, or a lead by setting back each course to form a series of steps.*

With old English and Flemish bond, the racking may show steps of as little as two inches. It is important that the racking bricks should be lined up and their faces kept plumb. Fig. 4,593 is an example of racking (and corbeling) as seen in the familiar chimney capping.

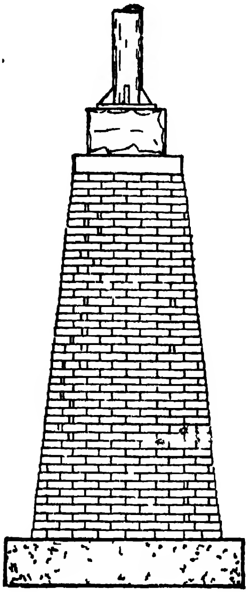


FIG 4,594 —Battered brick pier diminishing by ¼ in stepping from base to the top and capped with a bond stone on which a granite block is set and on which rests a cast iron column.

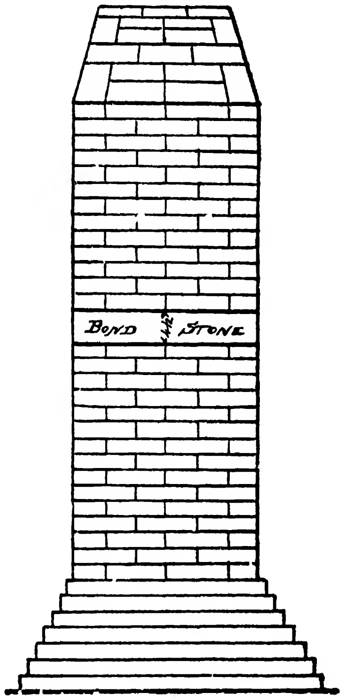


FIG 4,595 —Twenty four inch brick pier with stepped up base and one bond stone set 15 courses up This large pier is here represented in course of construction and involved much bricklaying and consequently careful bonding and full grouting It is strengthened for bearing purposes with bond stones properly spaced.

Battered Brickwork.—Some structures as high chimneys and towers, are built with walls not perpendicular but converging toward the top to give stability. This diminishing width or *batter* is the same as *racking* only in a much smaller degree. The degree of batter is expressed in inches per foot, per 5 ft., or per 10 ft., as the case may be.

CHAPTER 80

Repairing Old Brickwork

It often happens that because of defects in the design, poor material, settlement of foundations, damage is done to the brickwork, requiring repairs. The conditions just mentioned result in bulging walls, cracks and collapse of part of the brickwork.

Unsafe Walls.—The walls of buildings become unsafe from many causes, such as: bad judgment or haste in building, the natural decay of the materials, exposure to climatic changes and chemical action; long usage; overloading, etc. Foundation walls frequently bulge inward due to filling in the earth before the mortar has set; an example of haste as shown in fig. 4,596. The proper remedy is to re-excavate the fill at the bulge, remove this portion of the wall, then re-brick to its true position and give the mortar plenty of time to set.

If this be too expensive or impractical. the bulge could be reinforced by a buttress on the inside. If it be desired to use the space otherwise, the fill could be excavated and an outside buttress built being careful to strongly bond the buttress to the bulging brickwork. These remedies for a foundation bulge are shown in figs. 4,597 to 4,599.

A difficulty sometimes encountered is that of an adjoining building with walls out of plumb.

One method of treating such cases is to line up the overhanging wall with brickwork carrying it up plumb until it practically merges with the old wall, anchoring it to the latter with L anchors, and furring out the receding wall with tapered wood studding thus obtaining perpendicular surfaces. This method has the advantage that the tenants in the adjoining buildings are not disturbed.

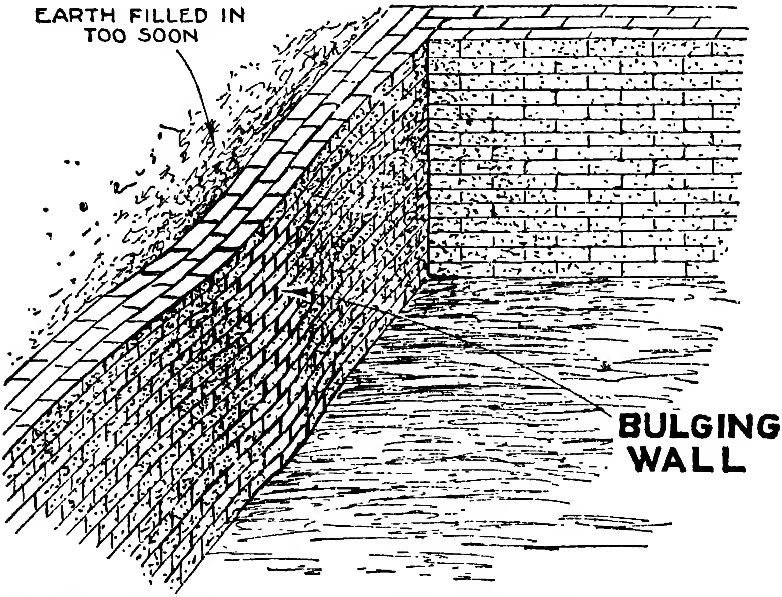


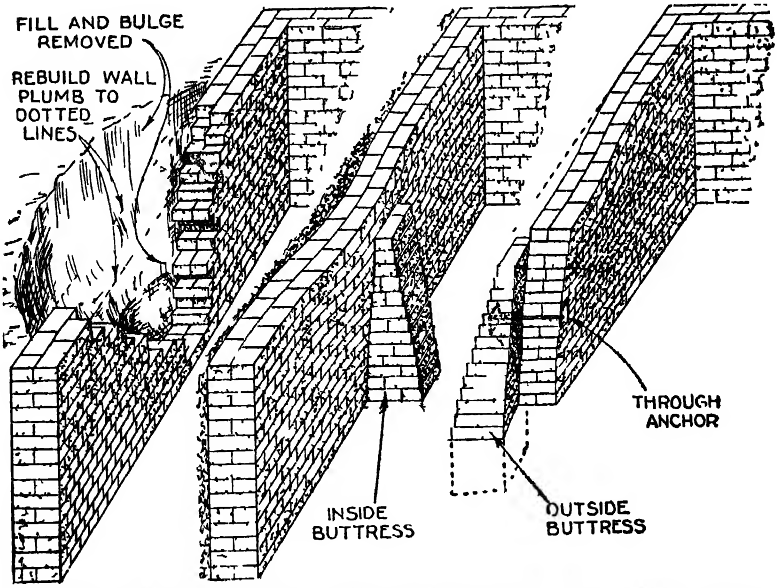
FIG. 4,596.—Bulging foundation wall due to filling in before mortar hardened.

Another source of trouble is buckled walls due to overloading in the center of the joist span.

Since the joists are securely anchored to the side walls of a building

any load sufficiently heavy or to cause them to bend will bring a lateral pressure on the walls tending to buckle them as shown in fig. 4,601. A simple truss method of stiffening joists to prevent buckling is shown in fig. 4,602.

Shoring.—The term *shoring* may be defined as the method of propping up a building or other structure by a timber



FIGS 4,597 to 4,599.—Remedies for a bulging foundation wall 1, rebuild the wall, fig. 4,597; reinforce by inside or outside buttress, figs 4,598 and 4,599

placed obliquely to it or under it. A timber used in this way is called a shore and acts as a strut, and is frequently resorted to in excavating foundations; this means placing timber struts

obliquely against the walls of a building to support it, should it be in danger of falling, or whenever alterations are being made to its base. Naturally, if an excavation be carried close to the walls of an existing structure, the pressure will

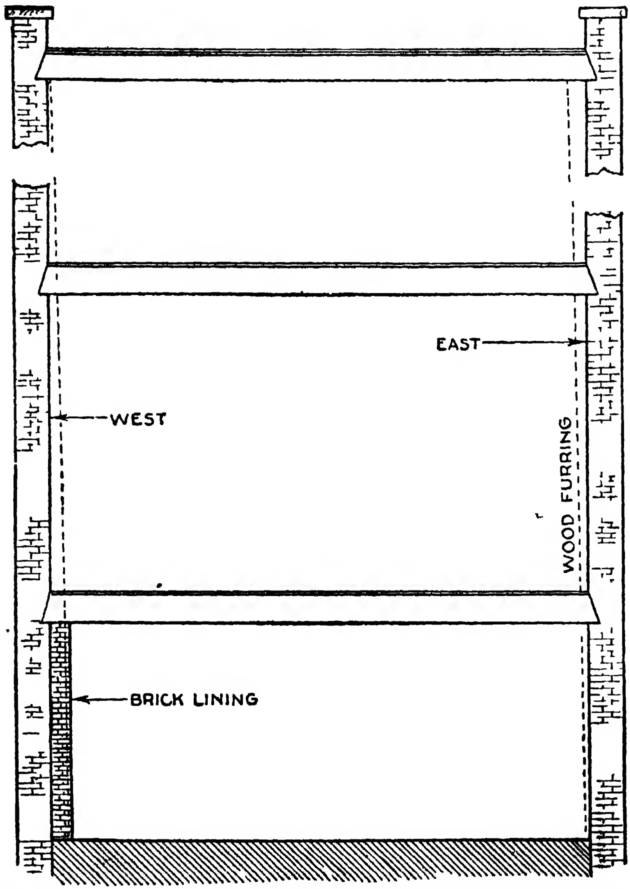
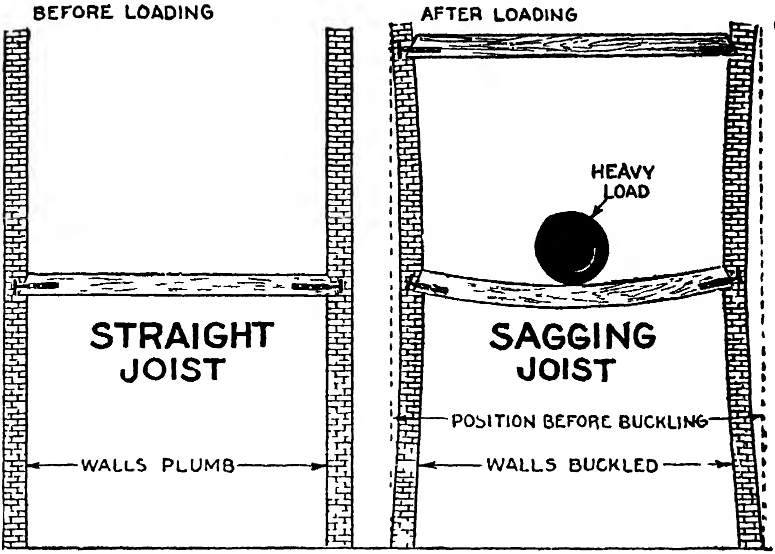


FIG. 4,600 —Leaning walls of adjoining buildings out of plumb and method of making plumb interior walls of building under construction



FIGS. 4,601 and 4,602 —*Before* and *after* overloading a floor, showing cause of bulged walls.

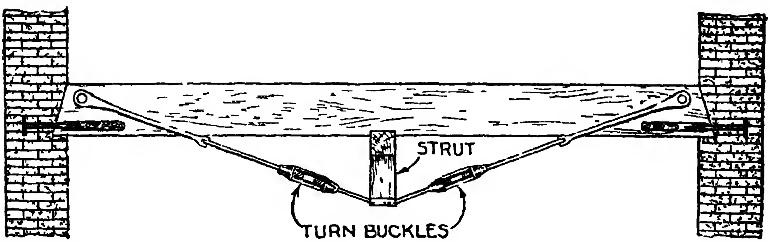


FIG 4,603 —Method of reinforcing joists with strut and tension rods to prevent sagging and resulting buckling of walls. *In design* make the strut of ample length to avoid undue tension in the rods

tend to force the footings sidewise, and a collapse is threatened.

Buckled walls may be shored as shown in fig. 4,604.

Here the end of the shore is placed against the wall and a substantial cross piece or bridge attached to the joists as shown. Where there is no footing to take the thrust of the shore, as the bridge attached to the joist in fig. 4,604, the brickwork must be partly cut away to receive the end of the shore as in fig. 4,605.

Often several shores of different length radiating from an

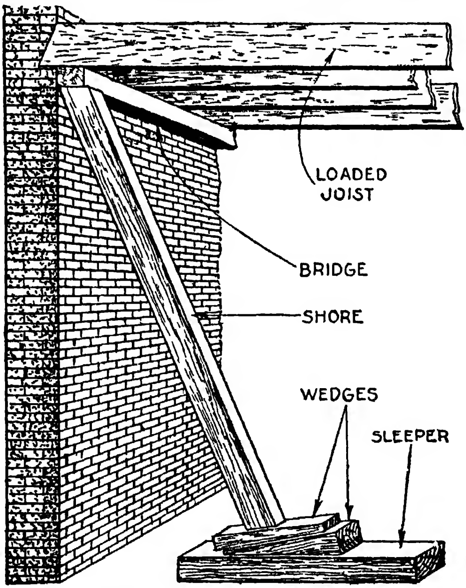


Fig. 4,604.—Shoring a bulged wall with inside shore.

outside point are used to brace an outwardly bulging wall at the different floors.

Here holes are cut in the face of the brickwork to secure the upper ends of the shores, while the bottom ends rest upon a sole plate or plates solidly embedded in the ground.

The following table gives the dimensions of raking or spur shore timbers of spruce or yellow pine.

Shore Table

For walls from	Inches	Inches
15 to 20 feet in height	4× 4 to	6× 6
20 " 30 " "	4× 8 "	6× 8
30 " 40 " "	6× 8 "	8×10
40 " 50 " "	8× 8 "	10×10
50 " 75 " "	10×12 "	12×14

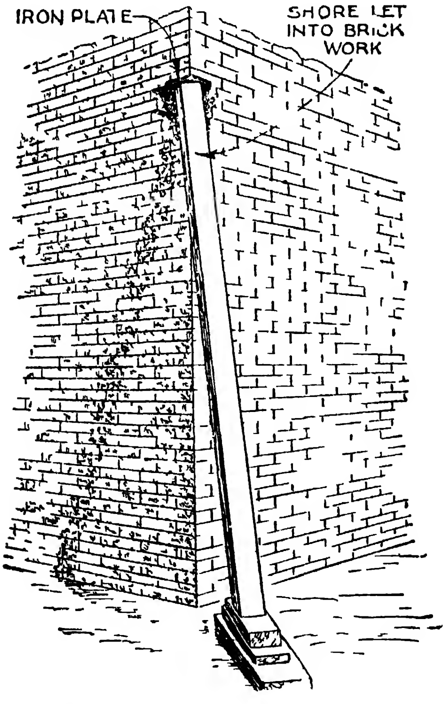


Fig 4,605 —Outside shore let into brick wall to secure footing Note plate which transmits the thrust from shore to the brick work

Beyond 75 ft. combinations of shores must be used. To prevent two parallel walls bulging, spreading braces or fly shores are placed as shown in fig. 4,606.

Where extra long fly shores must be used they are prevented sagging by diagonal braces framed in under them at the ends and spiked as indicated by the dotted lines.

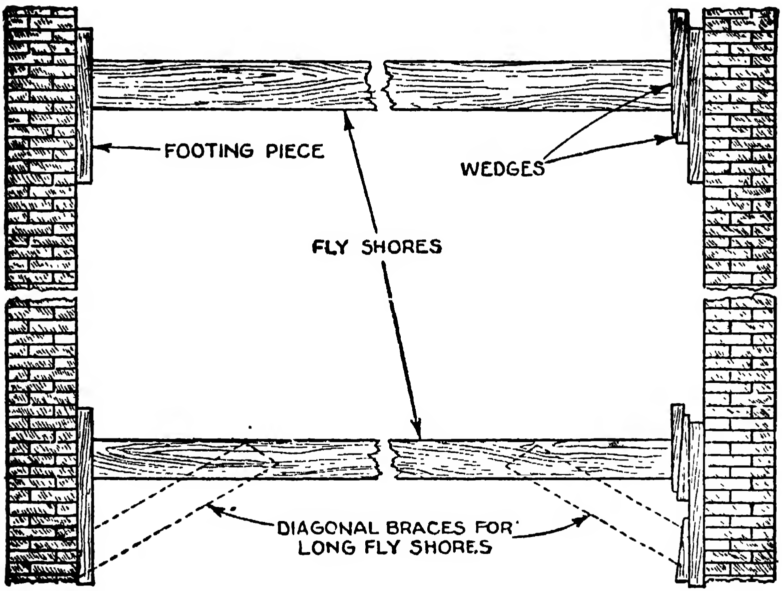
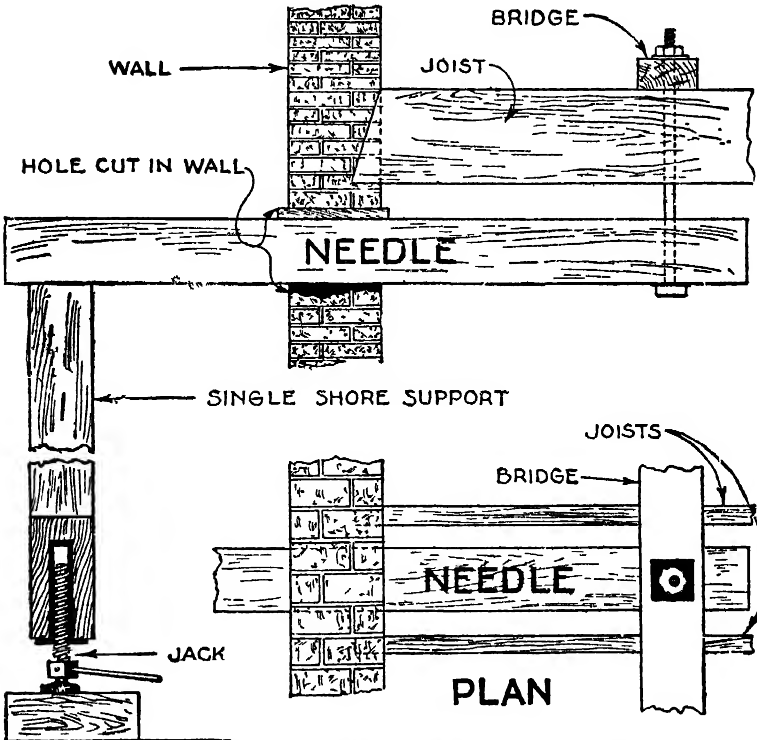


FIG. 4,606.—Walls of two adjacent buildings braced by fly shores.

Needling.—In repair work, the term *needle* means *a temporary support used by builders to sustain a wall when repairing, consisting of a heavy beam, supported by props.* More specifically it is *a heavy beam used for the temporary support of a wall during repairs, by threading it through an opening in the wall and supporting it by a prop at one end or at both ends.* as shown in figs.

4,607 to 4,610, respectively. Needling is attended with less risk than shoring.

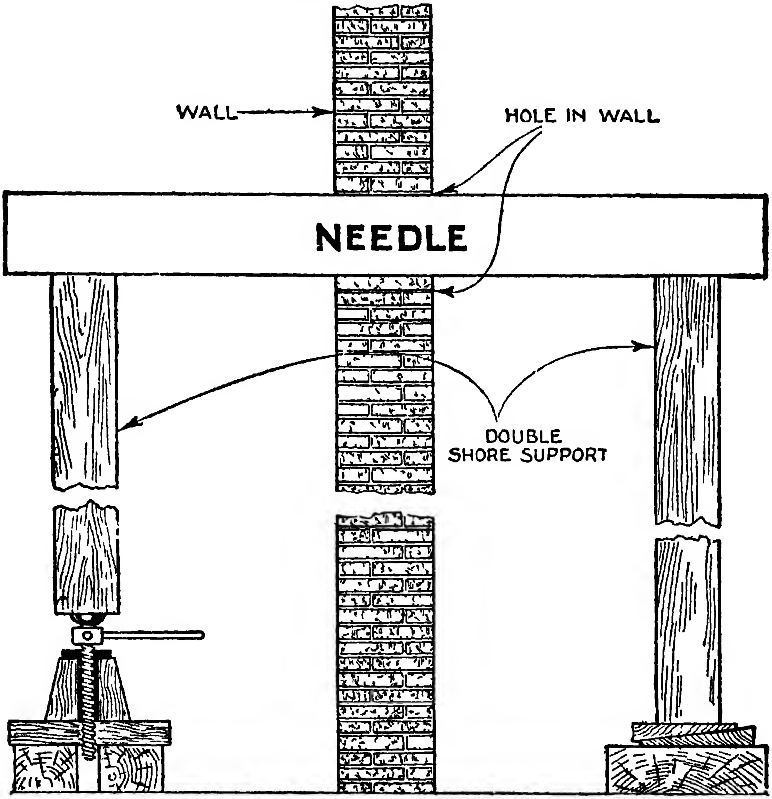
Underpinning.—When a new building with deep footings is



Figs. 4,607 and 4,608.—Method of supporting wall with *single shore needle.*

to be constructed adjoining an old building, the footings of which have not been carried down to the depth that is required for the new building, it is necessary to rebuild the

footings of the old building if the soil be not of such character as will give adequate support while the footings for the new buildings are being constructed. When new footings have to be built for the old building, underpinning is necessary.



FIGS. 4,609 and 4,610 —Method of supporting wall with *double shore needle.*

The usual method of underpinning is by the use of brick piers well bonded.

During the removal of the old footings and construction of these piers the wall of the building is supported by needling

The needles being in place and the weight of the wall having been transferred to them the footings are removed and piers constructed extending down to the level of the footings of the new building In first class work these piers are capped with two stones dressed top and bottom with iron wedges placed between them *After the mortar in the piers has hardened* these wedges are then driven between these stones in opposite pairs, one from the inside and the other from the outside, care being taken to drive

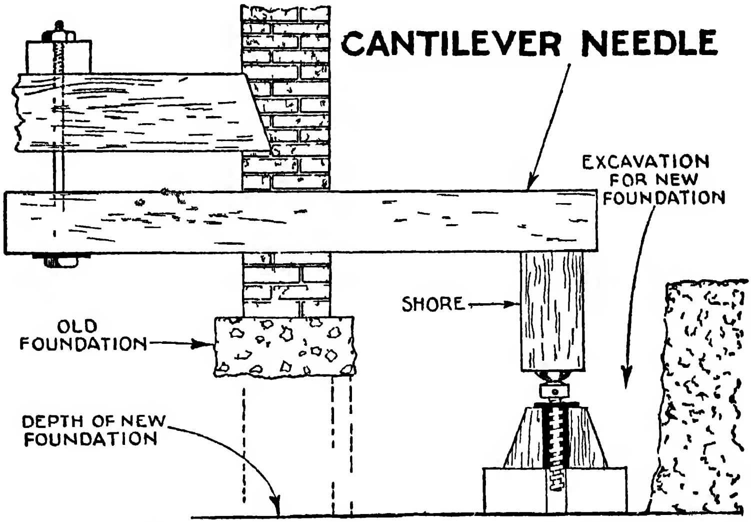


FIG 4 611 —Cantilever needle method of under pinning old building for the erection of new foundation or pier reinforcement to old foundation

them evenly from both sides They are driven home or until the top stone bears against the brick wall and then its weight is transferred from the needles to the piers This condition can be readily seen by the straightening of the needles when relieved of the loads

The sides between the piers are filled in with a light retaining wall, and the space between the cap stones grouted, the needles removed and holes bricked up The spacing of the piers, their size etc , will of course depend upon the conditions met with in any particular case these conditions

are so varied and so many that instructions cannot be given to meet every case.

In general it may be said that underpinning operations should be very carefully performed and should never be attempted except by those having considerable experience in this line.

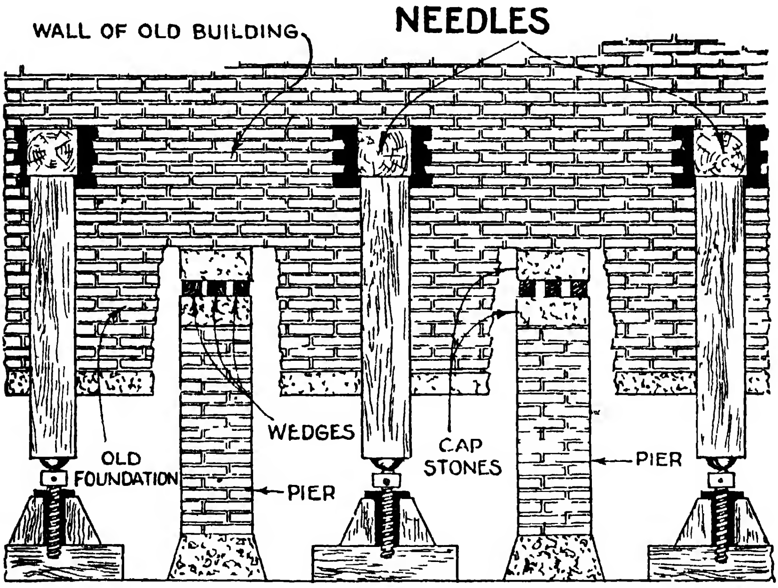
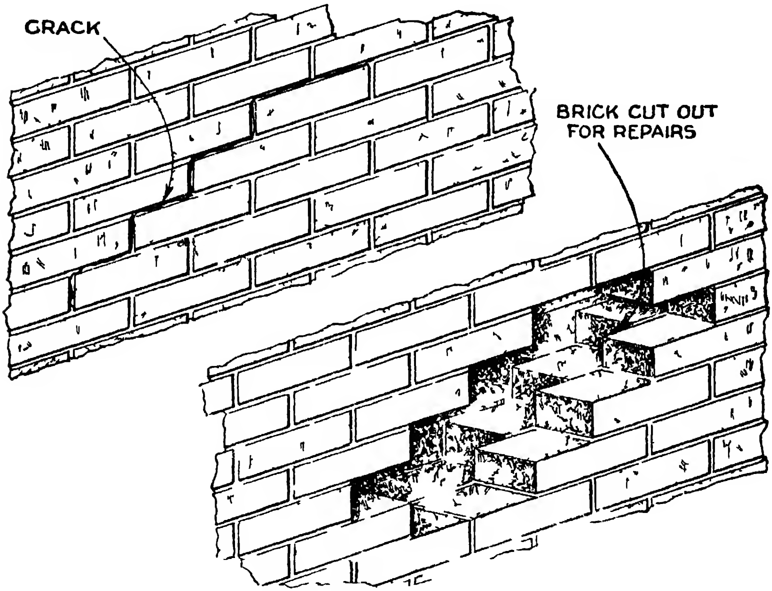


FIG. 4,612 —Side view of wall of old building supported by needles during the erection of piers extending down to level of foundation for new building.

Repairing Cracks.—Inadequate foundations, poor drainage or other causes which result in settling of foundations, cause cracks in walls.

In general, the settled portion of the foundation should be reinforced by piers or rebuilt and the walled pressed up to its

original position by capstones and wedges, the surface brick along the crack being cut out and the area rebricked. Where the wall is not pressed back into position the crack can be concealed by cutting out and rebricking, augmenting the joints to fill Figs. 4,613 and 4,614 show crack in wall and brick removed for repairs.

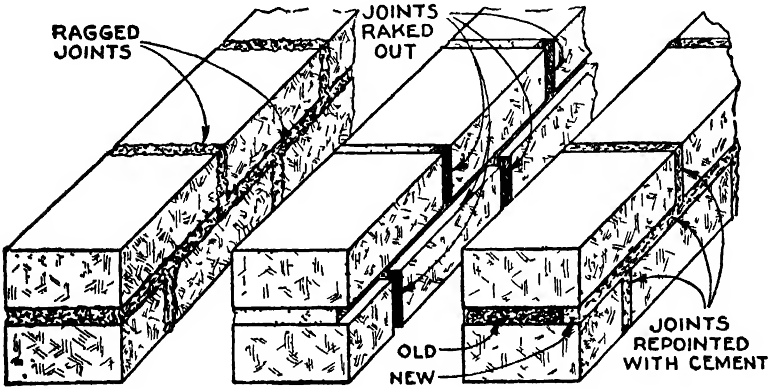


Figs. 4,613 and 4,614.—Appearance of crack in brick wall and brick cut out for repairs

Repointing.—After brickwork has aged, the mortar, especially if it be of inferior quality, will fall off more or less from the outer part of the joints. When this condition obtains, it is necessary both to preserve the strength and appearance of the brickwork to refill the joints, this operation is called repointing. It consists in raking out the decayed mortar from the joints to a depth of at least ¾ in. and filling the same

with cement or some hard setting mortar. Repointing is illustrated in figs. 4,615 to 4,617.

Cleaning.—Walls faced with pressed brick should be cleaned soon after completion. To do this a solution of muriatic acid and water is used in the proportion of from 15 to 20 parts of water to one part of acid. It is applied with scrubbing brushes



FIGS. 4,615 to 4 617 —Appearance of old brickwork joints and method of repointing them.

or brooms and the operation should be continued until all the stains are removed. While the cleaning is in progress, the open joints under all window sills should be pointed so that the wall will be left in perfect condition when the cleaning has been completed.

CHAPTER 81

Strength of Brickwork

The enormous strength of brickwork is not generally appreciated but the results of tests show that code requirements are in some cases too conservative, resulting in piers and walls unnecessarily expensive and bulky, taking up more room than is necessary.

The Common Brick Manufacturers' Association working with the U. S. Bureau of Standards and other bodies are conducting important investigations on the properties of brickwork which will result in exact engineering data upon which accurate formulae may be based. This will undoubtedly enable engineers, architects, and others to take full advantage of the great strength of brickwork by reducing the factor of safety, which heretofore, because of uncertainty as to the strength of brickwork, was unreasonably large.

Compressive Strength.—According to Prof. Ira O. Baker, "It would seem that reasonably good brick laid in good lime mortar should be safe under a pressure of 20 tons per sq. ft. and that the best brick in good Portland cement mortar should be safe under 30 tons per sq. ft." The compressive strength of individual brick as has been ascertained from tests, is extremely high. Brick from practically all the states have been tested and some of the results are given in the following table:

Compressive Strength of Individual Brick

(Tested Flat)

Brick	Lbs. per sq. in.	Tons per sq. ft.
Arkansas		
Red grade 1	12,253	953
" " 2	11,966	860
" " 3	5,620	406
Illinois		
Shale building brick	10,690	770
Underburned common	3,920	280
Kentucky		
Dark gray	20,030	1,442
Gray	16,793	1,210
Dark green	7,243	521
Red	5,290	380

The values given represent the ultimate crushing strength and the great range in strength of the various brick indicate the importance to specifying the kind of brick to be used when proportioning the brickwork for heavy stresses.

Strength of Mortar.—Tests at Columbia University by Prof. Macgregor indicate that while cubes of cement mortar are stronger than cubes of cement lime mortar, brickwork laid in cement lime mortar (using a 1—1—6 mixture) is stronger than when a straight 1—3 cement mortar is used, this being attributed to the increased plasticity given by the lime, resulting in a more thorough bedding of the brick and more complete filling of the joints calling into play less of the transverse strength of the brick units.

The Bureau of Standards tests showed practically no difference in strength of straight 1—3 Portland cement mortar and similar mortar in which 35% by volume of cement was replaced by lime.

Cement lime mortar is cheaper and saves bricklayers' time because of its greater plasticity. Lime mortar, while naturally weaker than cement or cement lime mortar, produces brickwork strong enough for many purposes.

Relative Strength of Individual Brick and Brickwork.—There are several factors which influence the strength of brickwork:

1. Strength of individual brick.
2. Strength of mortar.

FIG. 4,618.—Test piers for Racquet and Tennis Club building, New York City, illustrating strength of old brickwork age 16 years. These piers were taken for testing during the course of demolition of the building. The results of the tests are tabulated in the table on the next page.

3. Bond of brickwork.
4. Relation of length and thickness of wall or pier to unsupported height.

A sufficiently close ratio has not yet been established between the strength of individual brick and of brickwork. The strength of the latter is proportionate to both the compressive and transverse strength of the brick, although recent tests indicate that the strength of brickwork may be in closer

proportion to the transverse, than to the compressives trength of the units. Possibly the strength of brickwork may bear a closer relation to the tensile strength of the brick units rather than to their transverse or compressive strength.

Tests on Old Brickwork from Racquet and Tennis Club, New York City

By Rudolph P. Miller

Specimens	Height		Area in Compression Sq in	Ultimate Strength		First Crack at lb per sq in
	Inches	Courses		Total lbs	Per Sq in, lbs	
1	23½	9	193 60	268,970	*1,389	516
A	27⅛	10	206 25	181,000	877	640
B	24½	9	186 34	390 000	*2,093	1588
C	21⅝	8	196 00	365 000	*1 862	1275
*Average ultimate strength of specimens 1, B and C					1 781	lbs sq in.

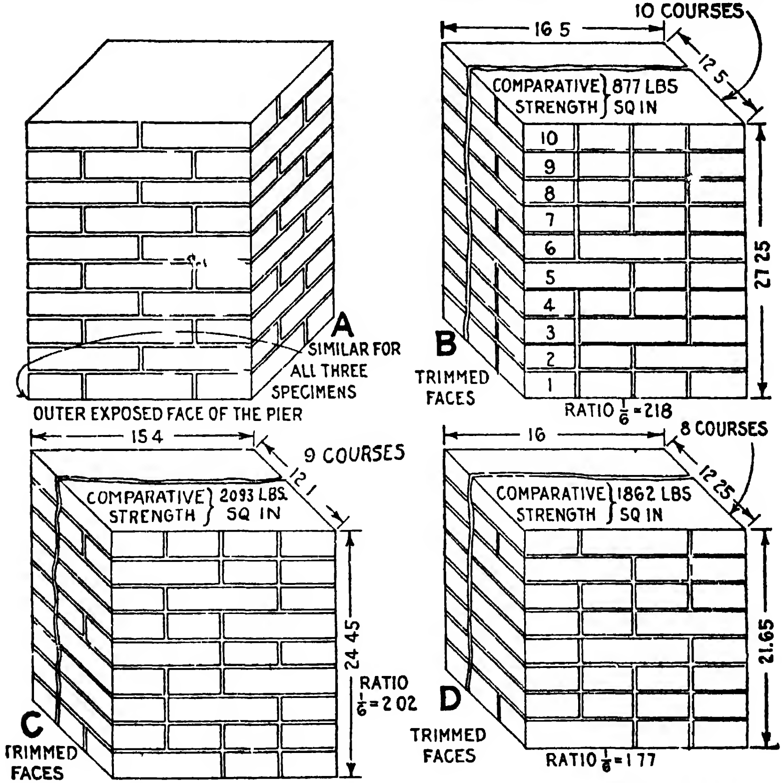
The bearing plate on Pier A was uneven and this is believed to be the cause of the lower recorded strength of his pier The average ultimate strength including Pier A is 1555 pounds per sq. inch.

Strength of Bonds in Piers.—According to the U. S. Bureau of Standards, "the opinion prevails that the tying in of masonry with header courses helps to strengthen piers against bulging action, thereby increasing the strength in proportion to the number of headers used." Results obtained in recent tests of brick piers, however, show that variations in the number of header courses used do not have a positive effect on the compressive strength of the pier.

The full strength of brickwork cannot be obtained without good bond.

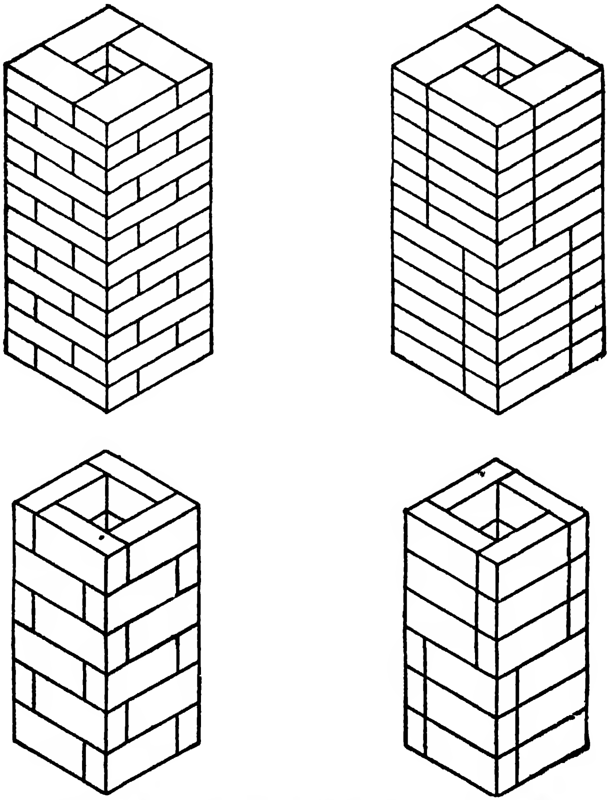
Stretchers develop longitudinal strength and headers, transverse strength. If the foundation of a brick wall settle unevenly, some stress will be caused in the direction of the length of the wall It would appear, therefore, to build a solid wall mostly of stretchers with just enough headers to tie it together.

Strength of Brick on Edge.—When tested to destruction, a pier fails by vertical cleavage, little crushing of the bricks being apparent, this being due to the unequal loading of the individual brick as the pier is compressed. It follows therefore that any method of construction which would increase the depth of the brick courses or the component parts of the pier



FIGS 4,619 to 4,622 —Test Pier specimens, showing bond and location of cracks first appearing. In all cases the cracks first appeared in the brick and started at some point where there was a void in the mortar joint, showing that there was an uneven pressure on different parts of the brick causing flexure in the brick with subsequent rupture

would increase its strength. In the Watertown Arsenal tests, this was done by laying the brick on edge; also by breaking joints every sixth course when laid flatwise and every third course when laid on edge. On these tests face brick were laid in 1:1 cement mortar.



FIGS. 4,623 to 4,626.—Piers used in the Watertown Arsenal tests. Fig. 4,623, pier with brick ***laid flat***, joints broken every course; fig. 4,624, pier with brick ***laid flat***, joints broken every sixth course; fig. 4,625, pier with brick ***on edge***, joints broken every course; fig 4,626, pier with brick ***on edge***, joints broken every third course

The following table shows the gain in strength (which would probably be greater for softer mortars).

Strength of Brick

(For various methods of laying)

Method of Laying	Percentage gain in strength
Brick flat	
Joints broken every course	0.
" " " sixth course	7.2
Brick on edge	
Joints broken every course	43.6
" " " third course	57.1

The following is a record of the above mentioned Watertown Arsenal tests:

Use of Brick on Edge Piers.—It would appear from the Watertown Arsenal tests that brick piers may be strengthened without increasing their area by using brick on edge. Projecting pilasters may sometimes be avoided by laying short lengths of wall of hollow or solid brickwork on edge where concentrated loads occur.

If brick on edge piers be built hollow, some method should be employed to hold brick units in place in case of severe fire. This may consist of a stout wire laid in the mortar joints of each or alternate courses. The wire should be continuous around the pier with ends lapping well over each other. It should be specially noted that the courses of brick on edge piers line with the courses of Ideal walls, thereby making it convenient and easy to bond Ideal wall construction to piers of brick on edge.

Strength of Piers Influenced by Height.—For a given size (cross area) of pier, the higher it is built the less its compressive strength. An elaborate series of tests were made on piers having the same cross area, and ratio of height to breadth varying from 4:3 to 78:8.

Influence of the Strength of Mortar on Piers
(Mortar· 1 lime, 3 sand Age, 28 days)

Pier No.	Compressive Strength of Bricks	Compressive Strength of Mortar	Mortar Mixture	Compressive Strength of Piers
	Lbs /in²	Lbs./in²		Lbs /in.²
1	4040	0	Dry sand	740
2	4040	38	1 lime, 3 sand	740
3	4040	355	2 lime, 1 cement, 9 sand	1420
4	4040	695	1 lime, 1 cement, 6 sand	1840
5	4040	1280	1 lime, 2 cement, 9 sand	1700
6	4040	1640	2 lime 1 cement, 7 sand	1930
7	4040	2620	1 cement 3 sand	1980

Influence of Varying the Height of Piers.
(Mortar 1 lime, 3 sand)

Pier No.	Compressive Strength of Bricks	Breadth of Pier	Ratio, Height to Breadth	Compressive Strength of Piers
	Lbs /in²	Inches		Lbs /in²
1	3260	10 6	4 3	2340
2	3260	10 6	8 7	2320
3	3260	10 6	13 0	1940
4	3260	10 6	17 4	1820
5	3260	10 6	21 7	1090
6	3260	10.6	26 4	1020
7	3260	10 6	30 7	Broken
8	3260	10 6	35 4	780
9	3260	10 6	39 5	880
10	3260	10 6	43 4	880
11	3260	10 6	48 8	750
12	3260	10 6	53 2	780
13	3260	10 6	57 5	640
14	3260	10 6	61 8	610
15	3260	10 6	65 8	660
16	3260	10 6	69 7	660
17	3260	10 6	74 5	610
18	3260	10 6	78 8	610

In these tests the compressive strength varied from 2,340 lbs. per sq. in. for the 4.3 ratio pier to 610 lbs. for the 78.8 ratio pier. In the brickwork the mortar was composed of 1 lime and 3 sand. These tests show how greatly the strength is influenced by height

According to the U. S. Bureau of Standards the important conclusions arrived at are:

1 That primary failure of piers is caused by transverse failure of individual brick.

2. The ultimate strength of the pier may be increased by any method of construction which increases the depth of the component parts of the pier. Laying brick on edge instead of flat; breaking joints every few courses instead of every course; or using brick of more than ordinary thickness are methods that will produce this result.

3. The ultimate strength of brick piers is proportional to the compressive and transverse strength of the brick.

Brick and Imitation Brick.—Genuine brick are burned. There are now on the market imitation brick which are not

FIG. 4,627.—Brick walls ready for testing.

burned and which have only a fraction of the strength weather resistiveness and fire resistiveness of real brick.

Recommended Thickness of Walls.—The walls of residential buildings, above the basement, where such walls do not exceed 30 ft. in height, may be safely built of solid brickwork 8 ins. thick. A gable of moderate height may be added to the

above without increasing the safe minimum allowable thickness of the walls. Basement walls should ordinarily be twelve ins. thick, unless the basement be shallow or soil conditions very favorable. Many large cities permit 8 in. walls for the usual residential building.

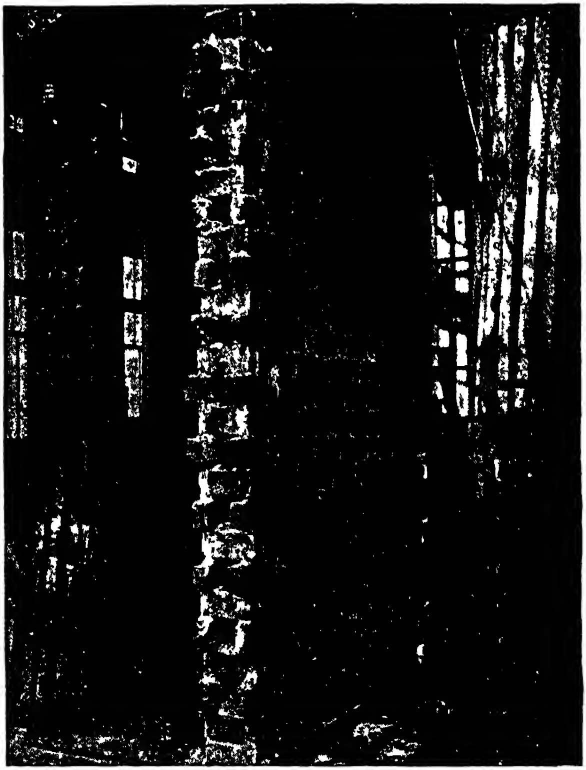


FIG. 4,628 —Eight-inch Ideal wall, 6 ft. wide and 9 ft. high, in ten million pound testing machine

***Thin Brick Partitions.**—For interior bearing or non-bearing partitions in residences the 4 in. brick wall is strong and much

more fire resistive than partitions of wooden studs and their use is recommended for at least some of the partitions in residences.

Such partitions have ample strength to carry floor joists at the first floor, second floor and attic levels. They must either extend up from the basement floor or be carried on steel joists at the basement ceiling level, supported on brick piers.

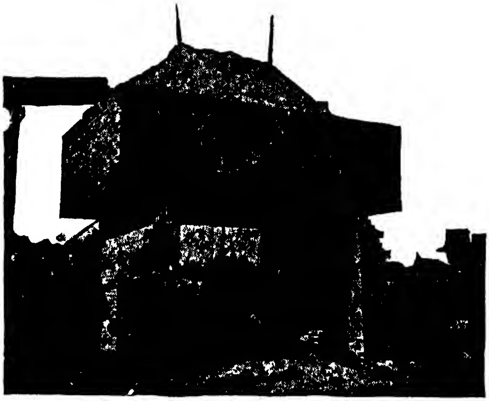


FIG. 4,629.—Eight inch ideal wall test structure designed by Virgil Allen formerly building commissioner of Cleveland and built for the inspection of the building officials conference, held in Cleveland, 1921. Sand box, sand and walls weigh 82 tons or 6,750 lbs. per ft. run at base of walls. No sign of distress observed.

Thickness of Ideal Walls.—Local ordinances govern the

NOTE.—*Quality and crushing strength of brick.* Theoretically, a brick of the very best quality should be regular and true in shape and free from kiln marks or depression caused by pressure of the brick above it in the kiln. It should be well burned throughout, free from lumps of lime, large pebbles, air bubbles or fissures, of firm compact texture and fairly even in color. It should give a clear ringing sound when struck a sharp blow with a hammer or against other brick. The crushing strength of brick is valuable mainly in comparing different brands or makes, and does not represent the strength of the brick masonry, as this strength is dependent on the strength of the mortar and care in laying, as much as on the strength of the brick. Consequently, the crushing strength of the brick is relatively not of great importance unless the mortar used is practically as strong as the brick, as would be the case with the use of cement or strong cement lime mortar.—*Hool and Johnson*

*NOTE.—In European countries it is standard construction to use 4 in. brick walls for bearing and non-bearing partitions in residences and other buildings having only moderate floor loads and ordinary story heights. Such walls are frequently built three stories high and support the joists at each floor level. Non-bearing partitions of brick on edge are used extensively also

permitted wall thicknesses in various localities. In their absence the following safe minimum thicknesses may be followed:

Above the first floor line the 8 in. wall is recommended for enclosing walls of two and one half story residences, residential buildings (such as apartments or club buildings), or other buildings having similar light floor loads and in which story heights and unsupported lengths of wall are not excessive.

For three story buildings similar to those described above, the first story should have a 12½ in. wall and an 8 in. wall, above and for four stories, the first and second story walls should be 12½ and 8 in. above.

For resisting earth pressure, basement walls for residences, whether the superstructure be brick, frame, or any other material, should ordinarily be 12½ ins. thick. Whether the basement be shallow or the soil dry and gravelly or of such consistency that earth pressure will not be excessive, basement walls for residences up to two and one-half stories high may, under favorable conditions, be built 8 ins. thick if of brick.

CHAPTER 82

How to Figure Brickwork

Estimating the number of brick in a wall would be a very simple operation were it not for the space taken up by the mortar. This latter item evidently varies with the thickness of the joint which ranges from ⅛ to ⅜ in. or more.

The number of brick considering the joints may be obtained by two methods:

1. By volume of the brickwork.
2. By area of the wall surface.

1. Volume Method

Unit of Measurement.—Considering both the brick and the mortar, the space taken up by each brick and mortar in the joint will depend upon whether one side of the brick be on the outside surface of the wall as in 4 and 8 in. walls, or whether the entire brick be covered by mortar as in the case of bricks in the center of a thick wall, also whether the brick be a stretcher or header.

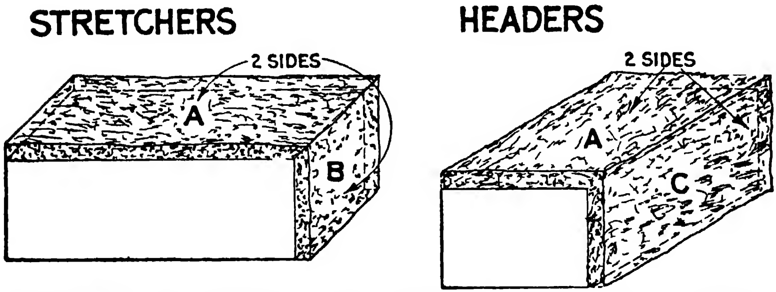
The space across the wall need not be considered as the net width of wall is taken in making the calculation.

Case 1. Stretchers.

This condition is shown in fig. 4,630. Hence the volume of mortar per brick will equal thickness of joint multiplied by sides A and B. Evidently the mortar in the central joint between the two rows of stretchers of an 8 in. wall or on both sides in a brick wall need not be considered as its thickness is not added to the thickness of the wall in figuring.

Case 2. Headers.

When brick are laid crosswise as in a header course, the



FIGS. 4,630 and 4,631.—Stretcher and header brick showing space taken up by the mortar.

space taken up by the mortar will be estimated by sides A and C of the brick as shown in fig. 4,631. Evidently a different amount of mortar is required for a header than for a stretcher.

Example.—Estimate the number of brick required for the small garage shown in figs. 4,632 and 4,633, 8 in. walls, 8 × 2¼ × 3¾ face brick with ¼ in. joints.

Rule.—*Determine net volume of the brickwork (deducting openings) and divide by volume of unit brick and mortar.*

$$\text{Gross volume sides} = 2\left(12 \times 9 \times \frac{7\tfrac{1}{2}}{12}\right) + 2\left(20 \times 9 \times \frac{7\tfrac{1}{2}}{12}\right) = 360 \text{ cu. ft.}$$

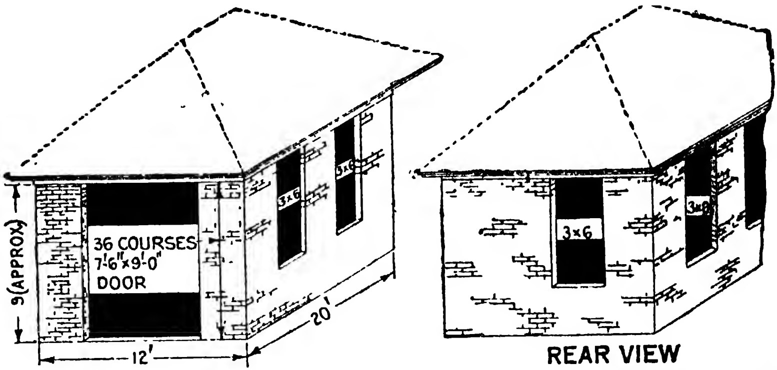
Deduct:

$$\text{Five } 3 \times 6 \text{ windows} = 5\left(3 \times 6 \times \frac{7\tfrac{1}{2}}{12}\right) = 56.3 \text{ cu. ft.}$$

$$\text{One } 7\tfrac{1}{2} \times 9 \text{ door} = 7\tfrac{1}{2} \times 9 \times \frac{7\tfrac{1}{2}}{12} = 42.2 \text{ “}$$

total deduction 98.5 cu. ft. 98.5 “ “

net volume brickwork 261.5 “ “



FIGS. 4,632 and 4,633.—Front and rear view of 12 × 20 garage with 8 in. brick walls, 36 courses.

Now for an $8 \times 2\tfrac{1}{4} \times 3\tfrac{3}{4}$ face brick unit with $\tfrac{1}{4}$ mortar joint volume of unit stretcher brick and mortar is as shown in fig. 4,636.

$$\text{Volume of unit brick and joint} = 8\tfrac{1}{4} \times 3\tfrac{3}{4} \times 2\tfrac{1}{2} = 77.35 \text{ cu. ins.}$$

To obtain number of brick in walls divide net volume of brickwork by volume of unit brick and joint. Since net volume of brickwork is in cu. ft. and volume of unit brick and joint is in cu. in. reduce the latter to cu ft. and divide, thus.

$$\text{Number of brick} = 261.5 \div \frac{77.35}{1{,}728} = 261.5 \times \frac{1{,}728}{77.35} = 5.842$$

2. Area Method

This method consists in computing the net area of the surface of the brickwork and multiplying the sq. ft. thus found by the number of brick required per sq. ft. of surface which gives the number of brick for a 4 in. wall. Evidently if the wall be 8 ins. thick twice the number of brick as above found would be required, etc. If the brick to be used measure approximately $8 \times 2\frac{1}{2} \times 3\frac{3}{4}$, the tables on pages 397 to 398 will be found

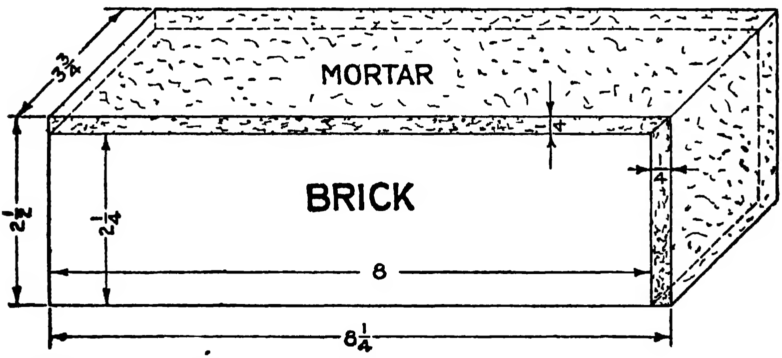


FIG. 4,634 —Unit stretcher brick with ¼ in mortar joint

convenient. The following tables issued by the Common Brick Association are provided to cover the principal variations from the size mentioned. Old fashioned, inaccurate rule of thumb methods for finding the number of brick in a wall are never used by up to date contractors.

The only way to arrive at the exact cost of the brick and mortar, and the time to lay them, is to figure the actual number of bricks to be used.

Number of Brick required for every square foot of Brick Wall 4″ to 4½″ thick

Size of Brick	⅜″ joints. No. of brick in each square foot.	½″ joints. No. of brick in each square foot.	⅝″ joints. No of brick in each square foot.
8¼ × 4 × 2¼......	6½	6	5¾
8¼ × 4 × 2½......	5¾	5½	5¼
8½ × 4⅛ × 2½......	5¾	5¼	5
8¾ × 4⅜ × 2¾......	5	4¾	4½

Number of Brick required for every square foot of Brick Wall 8″ to 9″ thick

Size of Brick	⅜″ joints. No. of brick in each square foot.	½″ joints. No. of brick in each square foot.	⅝″ joints. No. of brick in each square foot.
8¼ × 4 × 2¼.....	13	12	11½
8¼ × 4 × 2½.....	11½	11	10½
8½ × 4⅛ × 2½.....	11½	10½	10
8¾ × 4⅜ × 2¾.....	10	9½	9

Number of Brick required for every square foot of Brick Wall 12″ to 13″ thick

Size of Brick	⅜″ joints. No. of brick in each square foot.	½″ joints. No. of brick in each square foot.	⅝″ joints. No. of brick in each square foot.
8¼ × 4 × 2¼.....	19½	18	17¼
8¼ × 4 × 2½.....	17¼	16½	15¾
8½ × 4⅛ × 2½.....	17¼	15¾	15
8¾ × 4⅜ × 2¾.....	15	14¼	13½

Number of Brick required for every square foot of Brick Wall 16″ to 18″ thick

Size of Brick	¼″ joints. No. of brick in each square foot.	½″ joints. No. of brick in each square foot.	⅝″ joints. No. of brick in each square foot.
8¼ × 4 × 2¼.....	26	24	23
8¼ × 4 × 2½.....	23	22	21
8½ × 4⅛ × 2½.....	23	21	20
8¾ × 4⅜ × 2¾.....	20	19	18

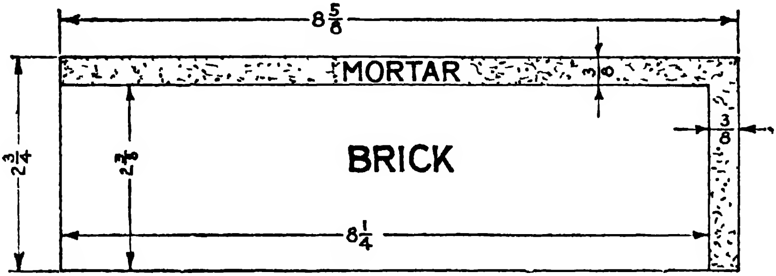


FIG. 4,635 —Brick and mortar joint illustrating the surface area method of calculation.

The following table is issued by the American Face Brick Association:

Number of Brick per sq. ft.

(Four inch wall; no headers)

Joint	⅛	¼	⅜	½	⅝	¾
No. of Brick	7½	7	6½	6⅛	5¾	5½

The table is calculated as follows: Using for illustration a brick 8¼ long by 2⅜ thick and a ⅜ in. mortar joint the length of brick + joint is 8¼ + ⅜ = 8⅝ as in fig. 4,635, and height

is $2\frac{1}{4} + \frac{3}{8} = 2\frac{5}{8}$. Hence the total area occupied in the wall by this brick with its mortar joint is:

$$8\tfrac{5}{8} \times 2\tfrac{5}{8} = 22.64 \text{ sq. ins.}$$

and the number of brick required per sq. ft. is:

$$144 \div 22.64 = 6.4 \text{ say } 6\tfrac{1}{2}$$

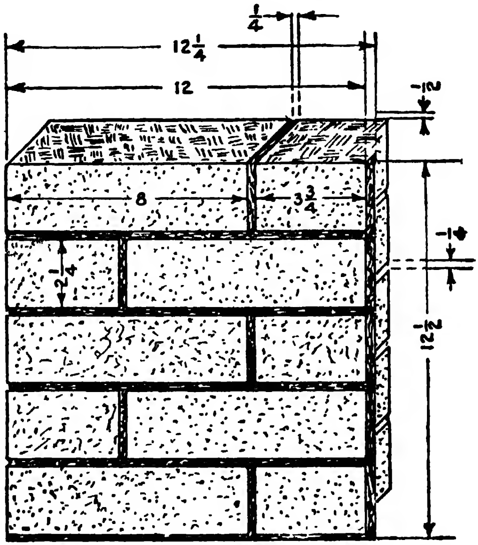


FIG. 4,636.—Nominal sq. ft. of wall surface with ¼ mortar joint illustrating surface method of estimating brick. Where a sq. ft. of brick work is laid up 3¾ ins. (4 ins.) thick with a ¼ inch joint. It shows 5 whole brick and 5 half brick or a total of 7½ bricks with a margin over 12″ in width of a ¼ inch and in depth a gain of ½ inch. Unless the work to be done be of greater proportions than the average house the rule generally employed by estimators is 7½ brick to the foot for a 4″ wall, 15 for an 8 in. wall, adding 7½ brick for each additional 4 in. of thickness. All openings are accurately deducted and a percentage varying from 5% to 10% added to cover wastage according to the number of rises and angles included in the work to be erected.

In estimating the whole number of brick, use no fraction less than the eight next above the fraction obtained in the number for the sq. ft., thus in the present case, count on using 6½ brick for every sq. ft. of wall area.

Example.—Estimate by the area method the number of brick (of size shown in fig. 4,634) required for the small garage shown in figs. 4,632 and 4,633.

Gross area of walls = 2 (12 × 9) + 2 (20 × 9) = 576 sq. ft.

Deduct:

Area of five 3 × 6 windows	= 5 (3 × 6) =	90 sq. ft.	
" " one 7½ × 9 door	= 7½ × 9 =	67.5 " "	
	total deduction =	157.5 " "	157 5 " "
		Net wall area	418.5 " "

In the table on page 398 look under ¼ in. joint and find 7 brick required per sq. ft. Hence, total number of brick required for garage is

$$(418.5 \times 7) \times 2 = 5{,}859 \text{ brick*}$$

It should be noted that this is for an 8 in. wall with stretcher bond without any header'cornices.

Estimating the Quantity of Common Bricks Required for Brick Walls of any Thickness.—Take the actual size of the bricks as manufactured in your community and add to this the thickness of the mortar joint, which will usually vary from ⅜ to ⅝ in thickness.

This will give you the number of sq. ins. of wall 4 or 4½ inches thick that one brick will cover. Divide 144 sq. ins. which is equivalent to one sq. ft., by the number of sq. ins. in one brick, and the result will be the number of bricks required to cover one sq. ft. of wall either 4 or 4½ ins. thick. If the wall is 8 or 9 ins. thick, which is equivalent to 2 bricks thick, multiply the result by 2, and the quotient will be the number of bricks required for one sq. ft. of brick wall 8 or 9 ins. thick. If the brick wall is 12 or 13 ins. thick, which is the width of 3 bricks, multiply the number of bricks required for one sq. ft. of wall 4 or 4½ ins. thick by 3, and the quotient will be the number of bricks required for one sq. ft. of wall either 12 or 13 ins. thick. This method may be used to compute the number of bricks required for one sq. ft. of brick wall of any thickness, by merely multiplying the number of bricks required for one sq. ft. of brick wall either 4 or 4½ ins. in thickness by the thickness of the wall in multiples of 4 or 4½ ins.

*NOTE.—5,859 brick as here obtained checks very closely with the number (5,842) obtained by the volume method. The reason for the difference in the result is because the figure 7 in the table is an approximation to avoid fraction and unnecessary figuring.

Number of Brick for Various Bonds.—The table given above is for brick laid in stretchers or running bond. Allowances must be made for the number of brick when other bonds using headers are employed. The percentages given in the following table are to be added to the number of brick required, as calculated by the use of the table given above:

Percentages Added for Various Bonds

Common bond	
a. Headers every fifth course	20% (1/5)
b. " " sixth "	16⅔% (1/6)
c. " " seventh "	14⅓% (1/7)
English or English cross bond	
Headers every sixth course	16⅔% (1/6)
Flemish bond	
Headers every sixth course	5⅔% (1/18)
Double header bond	
a. Two headers and a stretcher every sixth course	8⅓% (1/12)
b. " " " " " " fifth "	10% (1/10)

For garden walls, path walls and other places where an 8 in. wall is used, with face brick on both sides, no additional brick are required for any type of bond.

For walks and floors where the brick are laid on edge, in any pattern except diagonal ones, calculate the same as for the number of face brick in a wall laid in running bond.

For herringbone pattern or other diagonal work, an additional number of brick will be required to compensate for the clipping of the ends of the brick at the borders. The exact additional amount depends on the total width of the walk or floor, as the wider the surface the smaller will be the average wastage per sq. ft. Walks and floors where the brick are laid flat require ⅓ less than the number required where the brick are laid on edge.

Provided with the two tables given above it is a simple matter to calculate the number of face brick required for any job.

Example.—How many brick will be required for the small garage shown in fig. 4,632 and 4,633, for 8 in. wall, with brick laid in common bond, headers every sixth course? How many brick when laid in Flemish bond?

The number of brick as found for running or stretcher bond is 5,842. In the percentage table this number must be increased for common bond with headers every sixth course, $16\frac{2}{3}\%$, and for Flemish bond, $5\frac{2}{3}\%$. Hence number of brick for

Common bond, headers every sixth course $= 5{,}842 \times 1.16\frac{2}{3} = 6818$
Flemish bond........................ $= 5{,}842 \times 1.05\frac{2}{3} = 6175$

Wastage.—In figuring brick as above and the bricklayers be careful to use bats for closures and spalls for clinking in, instead of breaking bricks, no waste need be figured.

If the area of small openings (10 sq. ft. or less) be not deducted, a certain number of excess brick will be obtained which will allow for ordinary wastage.

Estimating Common Brick.—As the sizes of common brick, for all practical purposes, approximate the size of face brick, their quantity may be calculated on the same basis.

Thus, for a single thickness of common brick backing, the number required will be practically the same as that of the face brick laid in running board.

If, however, two or more thicknesses of backing brick be used, the proper deductions should be made for the thickness of the walls at the corners.

Rule.*—Multiply the number required for face brick by the number of thicknesses or tiers of the common brick backing, always considering the turns at the corners.*

When other than running bond is used in the facing brick, allowance should be made for the common brick displaced by the bonding face brick. The deduction in the number of

common brick, evidently just equals the increased number of face brick required for the bond selected.

Brick for Fireplaces.—In estimating quantities of common brick for fireplaces, figure the portions projecting beyond the line of the wall, such as hearth and ash pit, as if solid, that is, the number of brick for the surface multiplied by the number of tiers deep, and then deduct the number of brick displaced by all flues and openings, face brick facing, and fire brick lining.

Estimating the Mortar.—Portland cement is packed in bags of 94 lbs. net weight. Four bags make a barrel of 376 lbs. net. For ease of calculation, Portland cement is often assumed to weigh 400 lbs. gross or 380 lbs. per barrel and when proportioning, is figured to weigh 100 lbs. per cu. ft.

Lump lime is sold in bulk by the bushel, the bushel varying from 75 to 85 lbs. net.

It is also sold by the barrel. A 180 lb. barrel contains 3.1 cu. ft. and a 280 lb. barrel contains 4.7 cu. ft. A cu. ft. of lime weighs from 60 to 75 lbs. net.

The quantities given in the following table are based on a 380 lb. barrel of Portland cement; a 180 lb. barrel of lump lime, and a 50 lb. sack of hydrated lime.

NOTE.—Estimating the quantities of materials sufficient for one cubic yard of Portland cement mortar. When Portland cement is used to make mortar for laying common bricks, the material cost of the mortar is not only greatly increased, but also the labor cost for masons laying the bricks is increased; as cement mortar does not work as easily as lime mortar, and a mason is unable to lay as many bricks per hour or per day as on jobs where lime mortar is used. Cement mortar is usually mixed in the proportions of 1 part Portland cement and 2 parts sand with sufficient lime putty added to make the mortar work easily.

NOTE.—***Labor cost of slacking lime and making mortar.*** In slacking lime a mortar maker should slack and sand from 1¼ to 1½ barrels of lime per hour. This is at the rate of 10 to 12 barrels of lime per 8 hour day; 11¼ to 13½ barrels of lime per 9 hour day; and from 12½ to 15 barrels of lime per 10 hour day; and includes labor time adding the necessary sand to same. Including the time necessary to slack and sand the lime, a mortar maker should make about ½ cu. yd. of tempered mortar an hour. This is at the rate of 4 cu. yds. of mortar per 8 hour day; 4½ cu. yds. of mortar per 9 hour day; and 5 cu. yds. of mortar per 10 hour day.

Mortar required per 1,000 Brick

(⅜ joints)

PROPORTIONS	QUANTITIES		
	Cement	*Lime*	*Sand*
Cement Mortars			
1 part cement 2 parts sand	1¾ bbls.	¼ bbl optional	½ cu. yd.
1 part cement 2½ parts sand	1⅜ bbls	¼ bbl optional	½ cu. yd.
1 part cement 3 parts sand	1⅛ bbls	¼ bbl optional	½ cu. yd.
Lump Lime Mortars			
1 part lime 2 parts sand		⅞ bbl.	½ cu yd.
1 part lime 2½ parts sand		¾ bbl.	½ cu yd.
1 part lime 3 parts sand		⅝ bbl	½ cu yd
Hydrated Lime Mortar			
1 part lime 2 parts sand		3½ sacks	½ cu. yd.
1 part lime 2½ parts sand		3 sacks	½ cu. yd.
1 part lime 3 parts sand		2½ sacks	½ cu yd
Cement-Lime Mortars			
1 part cement 1 part lime 6 parts sand	½ bbl	1 sack hydrated, or ¼ bbl lump lime	½ cu yd.
Grout for $\frac{3}{16}$"-¼" Joints			
1 part cement 3 parts sand	approx. ¾ bbl.		approx. ⅓ cu yd.

Joints other than $\frac{3}{8}$ in. will require about $\frac{1}{3}$ more or less mortar for each $\frac{1}{8}$ in. difference.

Example.—How much cement lime mortar is required for the small garage brick laid in common bond?

The number of brick required for common bond as found is 6,818. Hence the quantities given in the table for cement lime mortar must be multiplied by $\frac{6,818}{1,000}$ or 6.82. Thus

Cement	= $\frac{1}{2}$ bbl.	× 6.82	= 3.41	say	$3\frac{1}{2}$ bbl.
Lime	= $\frac{1}{4}$ "	× 6.82	= 1.71	"	$1\frac{3}{4}$ "
Sand	= $\frac{1}{2}$ cu. yd.	× 6.82	= 3.41	"	$3\frac{1}{2}$ cu. yds.

Labor Mixing Mortar.—An experienced laborer will slake, sand and stack about $1\frac{3}{8}$ barrels of lime per hour, or 11 barrels per 8 hour day. The time required for mixing and tempering mortar per 1,000 brick varies from 1 to $1\frac{1}{2}$ hours, depending on the thickness of the mortar joints. These figures apply both for lime and cement mortar. For lime mortar it also includes the time required to slake the lime. One mortar mixer should supply eight bricklayers.

Example.—How much time is required for mixing the mortar for the small garage, brick laid common bond, allowing $1\frac{1}{2}$ hours per thousand brick?

The number of brick required for common bond as found is 6,818, hence

Time required $\frac{6,818}{1,000} \times 1\frac{1}{2} = 10\frac{1}{4}$ hours.

Labor Laying Brick.—On large work and in cities, bricklayers will lay 1,500 brick per day, including facing and backing.* This is for ordinary work, of course for special work such as pilasters, etc., or where special patterns must be formed on

* NOTE.—Mr. Thos. R. Preed, first vice-president of the Bricklayers, Masons and Plasterers International Union, states that a bricklayer in Chicago who does not lay 1,500 brick per day could not hope to hold his job.

the surface of the wall or for cornice work, the bricklayers' time should be increased according to the character of the work to be done.

Example.—How much time is required for laying brick (common bond) for the small garage assuming a rate of 1,500 brick laid per day?

Time required 6,818 ÷ 1,500 = 4.6 days

Summary

(Materials and labor for small garage, brick laid in common bond)

Materials	Brick	6,818
	Mortar — Cement	3½ bbls
	Mortar — Lime	1¾ "
	Mortar — Sand	3½ "
Labor	Mixing mortar	10¼ hours
	Laying brick	4.6 days

NOTE.—***The labor cost*** of laying all classes of common brick work will vary to a great extent with the class of work being performed, with the kind of mortar, whether laid in lime or cement mortar, and with the manner in which the work is handled by the superintendent or foreman in charge of the work. On heavy masonry walls a man will lay far more brick an hour than on a wall from 8 to 12 in. thick where the common bricks are used to back up face bricks, cut stone, granite or terra cotta. Also a man will lay more brick in lime mortar than in cement mortar on account of the lime mortar being much easier to handle and spread than cement mortar. All these conditions should be taken into consideration when estimating the cost of any class of brick masonry.

NOTE.—***Estimating*** the quantity of face or press bricks required. When estimating the quantity of face or press brick that are required for any job, take the entire area of the walls to be laid in face brick and total the same in square feet. The number of brick required for each square foot of wall will vary with the size of the brick and the mortar joints. After the quantity of square feet has been obtained, multiply the total number of square feet of face or press brick work by the number of bricks required for one square foot of wall, and the result will be the number of face bricks required for any particular piece of work. In making deductions for openings, such as doors, windows, etc., in face or press brick work, always note the size of the "reveal" or brick jamb. If the brick "reveal" or jamb return only 4 inches or the width of the brick, deductions should be made for the full size of the opening. If the brick "reveal" or jamb return either 8 or 12 inches, as the case may be, then the depth of the return of "reveal" must be deducted from the width of the door or window opening, as it will be necessary to cover this area with bricks and care must be taken not to make deductions for the full size of the openings in such instances.

Table 1.—Brick Footings, ½" Joints

Materials and labor for lengths in feet. Laborer's time includes mortar making. Cement mortar should be used. See table 7 for material needed for cub. ft. of mortar.

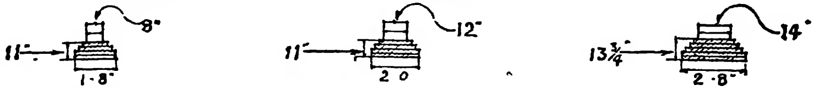


FIG. 4,637 to 4,639.—Various brick footings where properties are given in the accompanying table.

Length of Footing in Feet	8-INCH WALL					12-INCH WALL					16-INCH WALL					Length of Footing in Feet
				Bricklayer's Time Hours					Bricklayer's Time Hours					Bricklayer's Time Hours		
	No of Brick	Cu ft. of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	No of Brick	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	No of Brick	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	
1	22 713	385	176	129	165	28 106	477	218	160	204	45 945	780	366	230	285	1
2	46	1	⅓	¼	⅓	57	1	½	¼	½	92	2	¾	½	⅔	2
3	69	1½	½	½	½	85	1½	⅔	½	½	138	2½	1	⅔	1	3
4	91	2	⅔	½	½	113	2	1	⅔	¾	184	3½	1½	1	1⅛	4
5	114	2	1	⅔	¾	141	2½	1	¾	1	230	4	1¾	1¼	1½	5
6	137	2½	1	¾	1	169	3	1¼	1	1¼	276	5	2¼	1½	1¾	6
7	159	3	1¼	1	1⅛	197	3½	1½	1⅛	1½	322	6½	2½	1⅔	2	7
8	182	3½	1½	1	1¼	225	4	1¾	1¼	1¾	368	6½	3	2	2¼	8
9	205	3½	1½	1⅛	1½	253	4½	2	1½	1¾	414	7½	3¼	2¼	2½	9
10	228	4	1¾	1¼	1⅔	282	5	2¼	1½	2	460	8	3¾	2½	3	10
20	455	8	3½	2½	3⅓	563	10	4½	3¼	4	919	16	7¼	4¾	5¾	20
30	682	12	5¼	4	6	844	14½	6½	4¾	6	1378	24	11	7	8½	30
40	909	15	7	5¼	6½	1125	19	9	7	8	1837	31	15	9	11½	40
50	1136	20	9	7	8	1406	24	11	8	10	2296	39	18	12	14¼	50
100	2272	39	18	15	16	2812	48	22	16	20	4592	78	36	24	28½	100

Instructions for Using the Tables.—The accompanying tables of material and labor quantities for brickwork have been prepared for the Common Brick Manufacturers' Association by Mr. William Carver, architect, and author of an excellent book on brick. These tables which are very valuable and elaborate are here reproduced with his permission.

Table 2.—Exterior Basement Walls, 8 in. Walls, ½" Joints

Materials and labor for square foot areas. Exterior 4" thickness of wall laid with all joints filled. Remaining brick laid on a full bed of mortar, but brick touching end to end. Vertical space between each 4" thickness filled with mortar. Every 5th course a header course. Laborer's time includes mortar making. Cement-lime should generally be used for exterior basement walls. See Table 7 for materials needed for cubic feet of mortar.

Sq Ft Area of Wall	8-INCH WALL				
	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Bricklayer's Time Hours: Lime or Cement-lime Mortar	Bricklayer's Time Hours: Cement Mortar
1	12 706	.195	097	073	092
10	128	2	1	¾	1
20	255	4	2	1½	2
30	382	6	3	2½	3
40	509	8	4	3	4
50	636	10	5	4	5
60	763	12	6	4½	5½
70	890	14	7	5	6½
80	1017	16	8	6	7
90	1144	18	9	6½	8
100	1271	20	10	7	9
200	2542	39	20	15	19
300	3812	59	29	22	28
400	5083	78	39	29	37
500	6353	98	49	36	46
600	7624	117	58	44	56
700	8895	137	68	51	65
800	10,165	156	78	58	74
900	11,436	175	87	66	83
1,000	12,706	195	97	73	93
2,000	25,412	390	194	145	185
3,000	38,118	584	291	218	277
4,000	50,824	779	388	291	370
5,000	63,530	973	485	363	462
6 000	76,236	1168	582	436	555
7,000	88,942	1363	679	508	647
8,000	101,648	1557	776	581	739
9 000	114,353	1752	873	654	832
10 000	127 059	1947	970	726	924

The tables on page 398 and the following pages are designed to almost eliminate the calculations required to determine the amount of brick, mortar, laborers' time, and bricklayers' time to build a house or other building. They are based on a brick size of 8" × 2¼" × 3¾".

Example.—Figure the number of brick, materials required for mortar, laborers' and bricklayers' time required for 240 square feet of basement wall 12" thick. Referring to table No. 2 the number of brick required for

Table 2.—Exterior Basement Walls—*Continued*

(12 and 16 in. walls)

12-INCH WALL					16-INCH WALL					Sq. Ft. Area of Wall
			Bricklayer's Time Hours					Bricklayer's Time Hours		
No of Bricks	Cu ft. of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	
19 251	314	148	110	140	25 796	.433	199	129	159	1
193	3½	1½	1	1½	258	4½	2	1½	2	10
386	6½	3	2½	3	516	9	4	3	3½	20
578	9½	4½	3½	4½	774	13	6	4	5	30
771	13	6	4½	6	1032	18	8	5½	6½	40
963	16	7½	5½	7	1290	22	10	6½	8	50
1156	19	9	7	9	1548	26	12	8	9½	60
1348	22	11	8	10	1806	31	14	9	11½	70
1541	25	12	9	11	2064	35	16	10½	13	80
1733	28	14	10	13	2322	39	18	12	14½	90
1926	32	15	11	14	2580	44	20	13	16	100
3851	63	30	22	28	5160	87	40	26	32	200
5776	94	45	33	42	7740	130	60	39	48	300
7701	126	60	44	56	10 319	173	80	52	64	400
9626	157	74	55	70	12 899	217	100	65	80	500
11,551	189	89	66	84	15 479	260	120	78	95	600
13,476	220	104	77	98	18 058	303	140	90	111	700
15,402	251	120	88	112	20 638	347	160	103	127	800
17,327	283	134	99	126	23,218	390	180	116	143	900
19,252	314	149	110	140	25 797	433	200	129	159	1,000
38,503	628	297	220	280	51 594	866	400	258	318	2,000
57,754	942	445	330	420	77,391	1299	599	387	477	3,000
77,006	1255	594	440	560	103 188	1732	799	516	636	4,000
96,257	1569	742	550	700	125 984	2165	999	645	795	5,000
115,508	1883	890	660	840	154,781	2599	1199	774	954	6,000
134 760	2197	1039	770	980	180 578	3032	1398	903	1113	7,000
154,011	2511	1186	850	1120	206,375	3465	1598	1032	1272	8,000
173,262	2825	1336	990	1260	232,172	3898	1798	1161	1431	9,000
192 514	3139	1484	1100	1400	257,968	4331	1998	1290	1590	10,000

Continued from page 408

200 feet is 3,851, and for 40 feet 771, added together these equal 4,622 brick. Laborers' time for 200 square feet is 30 hours, and for 40 square feet is 6 hours, total 36 hours. Bricklayers' time for 200 square feet laid in cement-lime mortar is 22 hours, and for 40 square feet 4½ hours, total 26½ hours. Cubic feet of mortar totals 76 feet. Turning to table 7, we find 76 cubic feet of cement lime mortar requires 11 bags cement, 8 sacks hydrated lime, and 2¾ cubic yards of sand.

Laborers' time includes time for making and handling mortar, handling brick from pile on the ground, waiting on bricklayer, moving scaffold, etc.

Bricklayers' time is calculated on the basis of work ordinarily required for the construction of a house or other building. In case work has many special features, such as pilasters, etc., or where special patterns must be formed on the surface of the wall, or for cornice work, the bricklayers' time should be increased according to the character of the work to be done.

Table 3.—Exterior Walls Above Grade, 8 in. Wall, Common Bond, ½" Joint

Materials and labor for square foot areas. All joints in outside 4" thickness filled with mortar. Remaining brick laid on full bed of mortar but with brick touching end to end. Vertical space between each 4"

Sq. Ft. Area of Wall	8-INCH WALL				
				Bricklayer's Time Hours	
	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar
1	12 705	.135	.093	084	.002
10	128	1½	1	1	1
20	255	3	2	2	2
30	382	4½	3	2½	3
40	509	5½	4	3½	4
50	636	7	5	4	5
60	763	8½	5½	5	5½
70	890	9½	6½	6	6½
80	1,017	11	8	7	7½
90	1,144	12	8½	7½	8
100	1,271	14	9	8½	9
200	2,542	27	19	17	19
300	3,812	41	28	25	28
400	5,083	54	37	34	37
500	6,353	68	46	42	46
600	7,624	81	56	50	56
700	8,895	95	65	59	65
800	10,165	108	74	67	74
900	11,436	122	84	76	83
1,000	12,706	135	93	84	93
2,000	25,412	270	185	168	185
3,000	38,118	406	278	252	277
4 000	50,824	541	371	336	370
5,000	63,530	676	463	420	462
6,000	76,236	811	556	504	555
7,000	88,942	946	648	588	647
8,000	101,648	1081	741	672	739
9,000	114,353	1216	834	756	832
10,000	127,059	1351	926	840	924

thickness left open. Every 5th course a header course. Laborer's time includes mortar making. See Table 7 for materials needed for cubic feet of mortar

Table 3.—Exterior Walls Above Grade, Common Bond, ½" Joints—*Continued*

(12 and 16 in. walls)

12-INCH WALL					16-INCH WALL					
			Bricklayer's Time Hours					Bricklayer's Time Hours		
No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	Sq. Ft. Area of Wall
19.251	.194	139	128	140	25 796	.254	186	137	172	1
193	2	1½	1½	1½	258	3	2	1½	2	10
386	4	3	2½	3	516	5½	4	3	3½	20
578	6	4½	4	4	774	8	5½	4	5	30
771	8	5½	5½	5½	1032	10	8	5½	7	40
963	10	7	6½	7	1290	13	9	7	8½	50
1156	12	9	8	8½	1548	16	11	8	10½	60
1348	14	10	9	10	1806	18	13	9½	12	70
1541	16	11	10½	11	2064	21	15	11	14	80
1733	18	13	12	12½	2322	23	17	12½	15½	90
1926	20	14	13	14	2580	26	19	14	17	100
3851	39	28	26	28	5160	51	37	27	34	200
5776	59	42	38½	42	7740	77	56	41	52	300
7701	78	56	52	56	10,319	102	75	55	69	400
9626	98	70	64	70	12,899	127	93	69	86	500
11,551	117	84	77	84	15,479	153	112	82	103	600
13,476	137	98	90	98	18,058	178	131	96	120	700
15,402	156	112	102	112	20,638	204	149	110	138	800
17,327	176	126	115	126	23,218	229	168	123	155	800
19,252	195	140	128	140	25,797	255	187	137	172	1,000
38,503	339	279	256	280	51,594	509	373	274	344	2,000
57,754	585	419	384	420	77,391	764	560	411	516	3,000
77,006	779	558	512	560	103 188	1018	746	548	688	4,000
96,257	974	698	640	700	128,984	1272	933	685	860	5,000
115,508	1169	838	768	840	154,781	1527	1119	822	1032	6,000
134,760	1364	977	896	980	180,578	1781	1306	959	1204	7,000
154,011	1558	1117	1024	1120	206,375	2036	1492	1096	1376	8,000
173,262	1753	1256	1152	1260	232 172	2290	1679	1233	1548	9,000
192,514	1948	1396	1280	1400	257,968	2545	1865	1370	1720	10,000

Laborers' time for cleaning brickwork is not included in these tables and should be added.

A man should clean and scrub with muriatic acid and water about 95 sq. ft. of brickwork per hour.

In figuring the area of a wall, deduct all openings over ten feet square. In making an allowance for the area of a door opening, take the area of the door itself and not the masonry opening. Thus if a door 3′–0″×7′–0″ figure a deduction of 21 ft., although the masonry opening may be 3′–4″×7′–2″.

For a window opening figure the sash area (generally 4″ more in width and 6″ more in height than the glass dimensions for double hung windows.

Cost of Brickwork of Garage.—Estimating the wall to be as previously described 8″ thick and 9 ft. high with a distance around the building of 64 ft. totaling 576 square feet minus the openings it is found it will require for common bond 6,818 brick.

To this number must be added about 5% plus about 72 brick already saved from above amount in turning the 4 corners = 341 + 6,818 = 7,159 brick. Where there are no acute or obtuse angles to be erected and the walls plain as in the present case, where quantities are accurately figured 5% should be ample as a factor of safety by wastage.

Thus 7,159 brick at $21.00 per M.	=	$150.33
Above calculations are based on a mason laying 15 hundred brick per day. As a factor of safety we here average that he will lay 12 C per 8 hour day = 5.99 days @ $9.00 per day ...	=	53.91
Mixing mortar 10¼ hours @ 5.00 per 8 hour day.	=	6.41
3½ bbls. of Portland cement @ $3.20.		11.20
3½ cubic yards of sand @ 2.00.		7.00
Forward.		$228.85
1¾ bags of hydrated lime @ .90		1.58
Total.		$230.43

If a foundation of brick is to be laid, say 16″ deep with a sub base of 4 × 12″ topped by an 8″ wall 12″ high. Figure as before the four sides, 64 feet minus the width of door 7½ ft. You have 56½ feet requiring 1,240 brick or 56.5 cubic feet @ 88c. per cu. ft.	=	$49.72
Trenching 4 hours @ 62.5c per hour.		2.50
		$52.22

Table 4.—Exterior Walls in Flemish, English and English Cross Bonds; 8 in. Walls, ½ in. Joints

Materials and labor for square foot areas. Brick in outside 8″ thickness laid with ½″ joints, with as many vertical joints parallel to the length of the wall left open as possible. Remaining brick in thicker walls laid on full mortar bed, but with brick touching end to end and vertical space between each 4″ thickness left open. Laborer's time includes mortar making. See Table 7 for material needed for cubic feet of mortar.

Sq Ft Area of Wall	8-INCH WALL				
	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Bricklayer's Time Hours: Lime or Cement-lime Mortar	Bricklayer's Time Hours: Cement Mortar
1	12 320	.195	.095	.104	.109
10	124	2	1	1	1
20	247	4	2	2	2½
30	370	6	3	3½	3½
40	493	8	4	4½	4½
50	617	10	5	5½	5½
60	740	12	6	6½	0½
70	863	14	7	7½	8
80	986	16	7½	8½	9
90	1,109	18	9	10	10
100	1,233	20	10	11	11
200	2,465	39	19	21	22
300	3,697	59	29	31	33
400	4,929	78	38	42	44
500	6,161	98	47	52	55
600	7,393	117	57	62	66
700	8,625	137	66	73	77
800	9,857	156	76	83	88
900	11,089	175	85	94	99
1,000	12,321	195	95	104	110
2,000	24,642	390	189	208	219
3,000	36,963	584	284	311	329
4,000	49,284	779	378	415	438
5,000	61,605	973	473	519	548
6,000	73,926	1168	567	623	657
7,000	86,247	1363	662	726	767
8,000	98,567	1557	756	830	876
9,000	110,888	1752	851	934	986
10,000	123,200	1947	945	1038	1095

Example on the Use of the Tables.—The following example on estimating brick by Mr. Carver, illustrates the use of the elaborate series of tables accompanying, being an estimate for

Table 4.—Exterior Walls in Flemish, English and English Cross Bonds—*Continued*

(12 and 16 in. walls)

12-INCH WALL					16-INCH WALL					
			Bricklayer's Time Hours					Bricklayer's Time Hours		
No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	No of Bricks	Cu ft of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	Sq Ft Area of Wall
18 866	254	141	158	167	25 411	313	188	179	197	1
189	3	1½	1½	2	255	3½	2	2	2	10
378	5½	3	3½	3½	509	6½	4	3½	4	20
566	8	4½	5	5	763	9¼	6	5½	6	30
755	10½	6	6½	7	1017	13	8	7½	8	40
944	13	7	8	8½	1271	16	10	9	10	50
1132	16	9	10	10	1525	19	11	11	12	60
1321	18	10	11	12	1779	22	13	13	14	70
1510	21	12	13	14	2033	25	15	15	16	80
1698	23	13	14	15	2288	29	17	17	18	90
1887	26	14	16	17	2542	32	19	18	20	100
3774	51	28	32	34	5083	63	38	36	[illegible]	200
5660	77	43	48	51	7624	94	57	54	59	300
7547	102	57	64	67	10 165	126	76	72	79	400
9434	127	71	80	84	12 706	157	94	90	99	500
11 320	153	85	96	101	15 248	189	113	108	118	600
13 207	178	99	111	118	17 789	220	132	126	138	700
15 094	204	113	127	134	20 330	251	151	144	158	800
16 980	229	128	143	151	22 871	283	170	161	177	900
18 867	255	142	159	168	25 412	314	189	179	197	1,000
37,733	509	283	318	336	50 824	628	377	359	394	2,000
56 599	763	425	477	503	76 236	942	565	538	591	3 000
75 466	1017	566	636	671	101 648	1256	754	717	788	4 000
94 332	1272	708	795	839	127 059	1570	942	896	955	5,000
113 198	1526	849	953	1006	152 471	1884	1131	1075	1182	6,000
132 065	1780	990	1112	1174	177 883	2198	1319	1255	1379	7,000
150 931	2035	1132	1271	1342	203 295	2512	1508	1434	1576	8 000
169,797	2289	1273	1430	1510	228 706	2826	1696	1613	1773	9,000
188,664	2543	1415	1589	1677	254 118	3140	1885	1790	1970	10 000

the brick house shown in figs. 4,664 to 4,666 to include the exterior walls and certain interior partitions in solid brick. The numbers opposite each item will correspond to the items on estimate sheet on page 432 to which results of working are carried

Table 5.—Interior Walls Common Bond; 4 and 8 in. Walls; ½in. Joints

Materials and labor for square foot areas. Brick laid on full bed of mortar, but with brick touching end to end. Vertical space between each 4" thickness left open. Laborer's time includes mortar making. See Table 7 for material needed for cubic feet of mortar.

Sq. Ft.	4-INCH WALL				8-INCH WALL				
	No. of Bricks	Cu Ft. of Mortar	Laborer's Time Hours	Bricklayer's Time Hours Any Mortar	No. of Bricks	Cu Ft. of Mortar	Laborer's Time Hours	Bricklayer's Time Hours Lime or Cement-lime Mortar	Bricklayer's Time Hours Cement Mortar
1	6 545	.059	.047	058	13 091	119	094	.070	087
10	66	1	½	½	131	1½	1	1	1
20	131	1½	1	1½	262	2½	2	1½	2
30	197	2	1½	2	393	4	3	2	3
40	262	2½	2	2½	524	5	4	3	3½
50	328	3	2½	3	655	6	5	3½	4½
60	393	4	3	3½	786	7½	6	4	5½
70	459	4½	3½	4	917	8½	7	5	6
80	524	5	4	5	1,048	10	8	5½	7
90	590	5½	4½	5½	1,179	11	9	6½	8
100	655	6	5	6	1,310	12	10	7	9
200	1,310	12	10	12	2,619	24	19	14	18
300	1,964	18	14	18	3,928	36	28	21	26
400	2,619	24	19	23	5,237	48	38	28	35
500	3,273	30	24	29	6,546	60	47	35	44
600	3,928	36	28	35	7,855	72	57	42	52
700	4,582	42	33	41	9,164	84	66	49	61
800	5,237	48	38	47	10,473	96	75	56	70
900	5,891	54	43	52	11,782	108	85	63	78
1,000	6,546	60	47	58	13,091	120	94	70	87
2,000	13,091	120	94	116	26,182	239	188	140	174
3,000	19,637	179	141	174	39,273	358	282	210	261
4,000	26,182	239	188	232	52,364	478	376	280	348
5,000	32,728	299	235	290	65,455	597	470	350	435
6,000	39,273	358	282	348	78,546	716	564	420	552
7,000	45,819	418	329	406	91,637	835	658	490	609
8,000	52,374	478	376	464	104,728	955	752	560	696
9,000	58,910	537	423	522	117,819	1074	846	630	783
10,000	65,455	597	470	580	130,909	1193	940	700	870

Table 5.—Interior Walls Common Bond—*Continued*

(12 and 16 in. walls)

12-INCH WALL					16-INCH WALL					
			Bricklayer's Time Hours					Bricklayer's Time Hours		
No. of Bricks	Cu Ft. of Mortar	Laborer's Time Hours	Lime or Cement lime Mortar	Cement Mortar	No. of Bricks	Cu. Ft. of Mortar	Laborer's Time Hours	Lime or Cement-lime Mortar	Cement Mortar	Sq. Ft.
19.636	.178	.140	.105	.131	26.181	.238	.187	116	140	1
197	2	1½	1	1½	262	2½	2	1½	1½	10
393	4	3	2½	3	524	5	4	2½	3	20
590	5½	4½	3½	4	786	7½	6	3½	4	30
786	7½	6	4½	5½	1,048	10	8	5	6	40
982	9	7	5½	6½	1,310	12	10	6	7	50
1,179	11	9	6½	8	1,571	15	11	7	8	60
1,375	13	10	7½	9½	1,833	17	13	8½	10	70
1,571	15	11	8½	10½	2,095	19	15	9½	11	80
1,768	16	13	9½	12	2,357	22	17	10½	13	90
1,964	18	14	10½	13	2,619	24	19	12	14	100
3,928	36	28	21	26	5,237	48	38	23	28	200
5,891	54	42	32	39	7,855	72	57	35	42	300
7,855	72	57	42	52	10,473	96	75	46	56	400
9,819	90	71	53	66	13,091	120	94	58	70	500
11,782	108	85	63	79	15,710	143	113	70	84	600
13,746	126	99	74	92	18,328	167	132	81	98	700
15,710	143	113	84	105	20,946	191	150	93	112	800
17,673	161	127	95	117	23,564	215	169	104	126	900
19,637	179	141	105	131	26,182	239	188	116	140	1,000
39,273	358	282	210	262	52,364	478	376	232	280	2,000
58,910	537	423	315	393	78,546	716	564	348	420	3,000
78,546	716	564	420	524	104,728	955	752	464	560	4,000
98,182	895	705	525	655	130,909	1193	940	580	700	5,000
117,819	1074	846	630	786	157,091	1432	1127	696	840	6,000
137,455	1253	986	735	917	183,373	1671	1315	812	980	7,000
157,091	1432	1127	840	1048	209,455	1909	1503	928	1120	8,000
176,728	1611	1268	945	1179	235,637	2148	1691	1044	1260	9,000
196,364	1790	1409	1050	1310	261,818	2387	1879	1160	1400	10,000

Table 6.—Walls in All Bonds; 4 and 8 in. Walls; ½ in. Joints

All joints filled with mortar. Materials and labor for square foot areas. "Other bonds" includes Flemish, English and English Cross bonds. Laborer's time includes mortar making. See Table 7 for material needed for cubic feet of mortar.

Sq. Ft. Area of Wall	4-INCH WALL: No of Bricks	4-INCH WALL: Cu ft of Mortar	4-INCH WALL: Labor-er's Time	4-INCH WALL: Brick-layer's Time	8-INCH WALL: No. of Bricks	8-INCH WALL: Cu ft. of Mortar	8-INCH WALL: Labor-er's Time Hours	8-INCH WALL: Bricklayer's Time, Hours, Common Bond: Lime or cement-lime Mortar	8-INCH WALL: Bricklayer's Time, Hours, Common Bond: Cement Mortar	8-INCH WALL: Bricklayer's Time, Hours, Other Bonds: Lime or cement-lime Mortar	8-INCH WALL: Bricklayer's Time, Hours, Other Bonds: Cement Mortar
1	6 160	.075	.045	.062	12 320	.195	.095	.090	099	104	109
10	62	1	½	¾	124	2	1	1	1	1	1
20	124	2	1	1½	247	4	2	2	2	2	2½
30	185	2½	1½	2	370	6	3	3	3	3½	3½
40	247	3½	2	2½	493	8	4	3½	4	4½	4½
50	309	4	2½	3½	617	10	5	4½	5	5½	5½
60	370	5	3	4	740	12	6	5½	6	6½	6½
70	432	5½	3½	4½	863	14	7	6½	7	7½	8
80	493	6½	4	5	986	16	7½	7½	8	8½	9
90	555	7	4½	5½	1,109	18	9	8	9	10	10
100	617	8	5	6½	1,233	20	10	9	10	11	11
200	1,233	15	9	13	2,465	39	19	18	20	21	22
300	1,849	23	14	19	3,697	59	29	27	30	31	33
400	2,465	30	18	25	4,929	78	38	36	40	42	44
500	3,081	38	23	31	6,161	98	47	45	49	52	55
600	3,697	46	28	37	7,393	117	57	54	59	62	66
700	4,313	53	32	43	8,625	137	66	69	69	73	77
800	4,929	61	37	39	9,857	156	76	72	79	83	88
900	5,545	68	41	56	11,089	175	85	81	89	94	99
1,000	6,161	76	46	62	12,321	195	95	90	99	104	110
2,000	12,321	151	91	123	24,642	390	189	179	197	208	219
3,000	18,482	227	137	185	36,963	584	284	269	296	311	329
4,000	24,642	302	183	247	49,284	779	378	359	394	415	438
5,000	30,803	377	228	308	61,605	973	473	448	493	519	548
6,000	36,963	453	274	370	73,926	1168	567	538	592	623	657
7,000	43,124	528	320	431	86,247	1363	662	627	690	726	767
8,000	49,284	604	365	493	98,567	1557	756	717	789	830	876
9,000	55,444	679	411	555	110,888	1752	851	807	887	934	986
10,000	61,605	755	457	616	123,209	1947	945	896	986	1038	1095

Table 6.—Walls in All Bonds—*Continued*

(12 and 16 in. walls)

12-INCH WALL							16-INCH WALL							
			Bricklayer's Time, Hours							Bricklayer's Time, Hours				
			Common Bond		Other Bonds					Common Bond		Other Bonds		
No. of Bricks	Cu. ft of Mortar	Labor-er's Time Hours	Lime or cement-lime Mortar	Cement Mortar	Lime or cement-lime Mortar	Cement Mortar	No of Bricks	Cu ft of Mortar	Labor-er's Time Hours	Lime or cement-lime Mortar	Cement Mortar	Lime or cement-lime Mortar	Cement Mortar-	Sq. Ft. Area of Wall
18.481	.314	.143	.134	.148	.156	.164	24 641	.433	.192	.152	.179	.179	.197	1
185	3½	1½	1½	1½	½	2	247	4½	2	1½	2	2	2	10
370	6½	3	3	3	3½	3½	493	9	4	3	3½	3½	4	20
555	9½	4½	4	4½	5	5	740	13	6	4½	5½	5½	6	30
740	13	6	5½	6	6½	6½	986	17½	8	6	7½	7½	8	40
925	16	7½	7	7½	8	8½	1,233	22	10	8	9	9	10	50
1,109	19	9	8	9	9	10	1,479	26	12	9	11	11	12	60
1,294	22	10	10	11	11	12	1,725	31	14	11	13	13	14	70
1,479	25	12	11	12	13	13	1,972	35	16	12	15	15	16	80
1,664	28	13	12	13	14	15	2,218	39	17	14	16	17	18	90
1,849	32	15	14	15	16	17	2,465	44	19	15	18	18	20	100
3,697	63	29	27	30	31	33	4,929	87	39	30	36	36	39	200
5,545	94	43	41	45	47	49	7,393	130	58	46	54	54	59	300
7,393	126	58	54	59	62	66	9,857	173	77	61	72	72	79	400
9,241	157	72	67	74	78	82	12,321	217	96	76	90	90	99	500
11,089	189	86	81	89	94	99	14,786	260	118	91	108	108	118	600
12,937	220	101	94	104	109	115	17,250	303	135	106	125	126	138	700
14,786	251	115	108	118	125	131	19,714	347	154	122	143	144	158	800
16.634	283	129	121	133	140	148	22,178	390	173	137	161	161	177	900
18,482	314	144	135	148	156	164	24,642	433	192	152	179	179	197	1,000
36,963	628	287	269	296	311	328	49,284	866	385	304	359	359	394	2,000
55,444	942	430	403	444	467	492	73,926	1299	577	451	538	538	591	3,000
73,926	1255	574	538	592	623	657	98,567	1732	769	608	717	717	788	4,000
92,407	1569	717	672	739	778	721	123,209	2165	961	760	896	896	985	5,000
110,888	1883	860	807	887	934	985	147,851	2599	1154	912	1075	1076	1182	6,000
129,370	2197	1004	941	1035	1090	1149	172,493	3032	1346	1064	1255	1255	1379	7,000
147,851	2511	1147	1075	1183	1245	1313	197,124	3465	1538	1216	1434	1434	1576	8,000
166,332	2825	1291	1210	1331	1401	1478	221,776	3898	1730	1368	1613	1613	1773	9,000
184,813	3139	1434	1344	1479	1557	1643	246,418	4331	1923	1520	1792	1790	1970	10,000

Size of House.

Dimensions are 26′—0″ wide and 30′—0″ deep with veranda 10′—0″ wide.

Table 7.—Quantities of Materials for Cu. Ft. of Mortar in Other Tables

(Lime mortar and cement-lime mortar)

Quantities of lime are based on the 180 pound barrel of good quality lime. Lime quantities are approximate, and will vary with the grade of lime and the size of particles composing the sand

Cu Ft. Mortar	LIME MORTAR 1 : 2				LIME MORTAR 1 : 2½				CEMENT-LIME MORTAR 1 : 1 : 6				
	Bbls. lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand	Bbls lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand	Bags of Cement	Bbls. lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand
1	.074	or	.315	037	056	or	236	.037	.130	024	or	104	037
2	⅙	or	⅝	1/16	⅛	or	½	1/16	¼	1/16	or	¼	1/16
3	¼	or	1	⅛	⅙	or	¾	⅛	⅜	1/16	or	⅜	⅛
4	5/16	or	1¼	⅛	¼	or	1	⅛	½	⅛	or	⅜	⅛
5	⅜	or	1⅝	3/16	5/16	or	1¼	3/16	⅝	⅛	or	½	3/16
6	½	or	2	¼	⅜	or	1½	¼	⅞	⅛	or	⅝	¼
7	⅝	or	2¼	¼	⅜	or	1⅝	¼	1	¼	or	¾	¼
8	⅝	or	2½	5/16	½	or	2	5/16	1⅛	¼	or	⅞	5/16
9	¾	or	2⅞	⅜	½	or	2⅛	⅜	1¼	¼	or	1	⅜
10	¾	or	3⅛	⅜	9/16	or	2⅜	⅜	1⅜	¼	or	1⅛	⅜
11	⅞	or	3½	⅜	⅝	or	2⅝	⅜	1½	⅜	or	1⅛	⅜
12	1	or	3⅞	½	¾	or	2⅞	½	1⅝	⅜	or	1¼	½
13	1	or	4⅛	½	¾	or	3⅛	½	1¾	⅜	or	1⅜	½
14	1⅛	or	4½	½	⅞	or	3⅜	½	1⅞	⅜	or	1½	½
15	1⅛	or	4¾	9/16	⅞	or	3½	9/16	2	⅜	or	1⅝	9/16
16	1¼	or	5⅛	⅝	1	or	3⅞	⅝	2⅛	½	or	1⅝	⅝
17	1¼	or	5⅜	⅝	1	or	4⅛	⅝	2¼	½	or	1¾	⅝
18	1⅜	or	5¾	⅔	1	or	4¼	⅔	2⅜	½	or	1⅞	⅔
19	1½	or	6	¾	1⅛	or	4½	¾	2½	½	or	2	¾
20	1½	or	6⅜	¾	1⅛	or	4¾	¾	2⅝	½	or	2⅛	¾
30	2¼	or	9½	1⅛	1¾	or	7⅛	1⅛	4	¾	or	3⅛	1⅛
40	3	or	12⅝	1½	2¼	or	9½	1½	5¼	1	or	4¼	1½
50	3¾	or	15¾	1⅞	2⅞	or	11⅞	1⅞	6½	1¼	or	5¼	1⅞
60	4½	or	19	2¼	3⅜	or	14¼	2¼	7⅞	1½	or	6¼	2¼
70	5¼	or	22⅛	2⅝	4	or	16½	2⅝	9⅛	1¾	or	7¼	2⅝
80	6	or	25¼	3	4½	or	19	3	10⅜	2	or	8⅜	3
90	6¾	or	28⅜	3⅜	5	or	21¼	3⅜	11¾	2¼	or	9⅜	3⅜
100	7½	or	31½	3¾	5⅝	or	23⅝	3¾	13	2½	or	10⅜	3¾
200	15	or	63	8	12	or	48	8	26	5	or	21	8
300	23	or	95	12	17	or	71	12	39	8	or	32	12
400	30	or	126	15	23	or	95	15	52	10	or	42	15
500	38	or	158	19	28	or	119	19	65	13	or	52	19
600	45	or	189	23	34	or	142	23	78	15	or	63	23
700	52	or	221	26	39	or	166	26	91	18	or	73	26
800	60	or	252	30	45	or	189	30	104	20	or	83	30
900	67	or	284	34	50	or	213	34	117	22	or	94	34
1,000	75	or	315	38	56	or	327	38	130	25	or	104	38
2,000	149	or	630	75	112	or	473	75	260	49	or	208	75
3,000	223	or	945	112	167	or	709	112	389	74	or	312	112
4,000	297	or	1260	149	223	or	945	149	519	98	or	415	149
5,000	371	or	1575	186	278	or	1181	186	649	123	or	519	186

Table 7.—Quantities of Materials for Cu. Ft. of Mortar in Other Tables—*Con.*

(Cement mortar)

CEMENT MORTAR 1 : 2 Bags of Cement	Bbls. lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand	CEMENT MORTAR 1 : 2½ Bags of Cement	Bbls. lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand	CEMENT MORTAR 1 : 3 Bags of Cement	Bbls. lump Lime	or	Sacks hydrated Lime	Cubic Yards Sand	Cu. Ft. Mortar
.494	.019	or	.079	.034	.424	.019	or	.079	.037	.370	.019	or	.079	.037	1
1	⅛	or	¼	⅛	⅞	⅛	or	¼	⅛	¾	⅛	or	¼	⅛	2
1½	⅛	or	¼	⅛	1¼	⅛	or	¼	⅛	1⅛	⅛	or	¼	⅛	3
2	⅛	or	⅜	⅛	1⅝	⅛	or	⅜	⅛	1½	⅛	or	⅜	⅛	4
2½	⅛	or	½	¼	2⅛	⅛	or	½	¼	1⅞	⅛	or	½	¼	5
3	⅛	or	½	¼	2½	⅛	or	½	¼	2¼	⅛	or	½	¼	6
3½	¼	or	⅝	¼	3	¼	or	⅝	¼	2⅝	¼	or	⅝	¼	7
4	¼	or	⅝	¼	3⅜	¼	or	⅝	⅜	3	¼	or	⅝	⅜	8
4½	¼	or	¾	⅜	3⅞	¼	or	¾	⅜	3⅜	¼	or	¾	⅜	9
5	¼	or	⅞	⅜	4¼	¼	or	⅞	⅜	3¾	¼	or	⅞	⅜	10
5½	¼	or	⅞	⅜	4⅝	¼	or	⅞	½	4⅛	¼	or	⅞	½	11
6	¼	or	1	½	5⅛	¼	or	1	½	4½	¼	or	1	½	12
6½	¼	or	1⅛	½	5½	¼	or	1⅛	½	4⅞	¼	or	1⅛	½	13
7	⅜	or	1⅛	½	6	⅜	or	1⅛	½	5¼	⅜	or	1⅛	½	14
7½	⅜	or	1¼	½	6⅜	⅜	or	1¼	⅝	5⅝	⅜	or	1¼	⅝	15
8	⅜	or	1¼	⅝	6¾	⅜	or	1¼	⅝	6	⅜	or	1¼	⅝	16
8½	⅜	or	1⅜	⅝	7¼	⅜	or	1⅜	⅝	6⅜	⅜	or	1⅜	⅝	17
9	⅜	or	1½	⅝	7⅝	⅜	or	1½	⅝	6⅝	⅜	or	1½	⅝	18
9½	⅜	or	1½	⅝	8⅛	⅜	or	1½	¾	7⅛	⅜	or	1½	¾	19
9⅞	⅜	or	1⅝	¾	8½	⅜	or	1⅝	¾	7½	⅜	or	1⅝	¾	20
14¾	⅝	or	2⅜	1⅛	12¾	⅝	or	2⅜	1⅛	11⅛	⅝	or	2⅜	1⅛	30
19¾	¾	or	3⅛	1⅜	17	¾	or	3⅛	1½	14⅞	¾	or	3⅛	1½	40
24¾	1	or	4	1¾	21¼	1	or	4	1⅞	18⅝	1	or	4	1⅞	50
29⅝	1⅛	or	3¾	2⅛	25½	1⅛	or	4¾	2¼	22¼	1⅛	or	4¾	2¼	60
34½	1⅜	or	5½	2⅜	29¾	1⅜	or	5½	2⅝	26	1⅜	or	5½	2⅝	70
39½	1½	or	6⅜	2¾	34	1½	or	6⅜	3	29⅝	1½	or	6⅜	3	80
44½	1¾	or	7⅛	3⅛	38¼	1¾	or	7⅛	3⅜	33⅜	1¾	or	7⅛	3⅜	90
49⅜	1⅞	or	7⅞	3⅜	42⅜	1⅞	or	7⅞	3¾	37⅛	1⅞	or	7⅞	3¾	100
99	4	or	16	7	85	4	or	16	8	75	4	or	16	8	200
149	6	or	24	11	128	6	or	24	12	112	6	or	24	12	300
198	8	or	32	14	170	8	or	32	15	149	8	or	32	15	400
247	10	or	40	18	212	10	or	40	19	186	10	or	40	19	500
297	12	or	48	21	225	12	or	48	23	223	12	or	48	23	600
346	13	or	56	25	297	13	or	56	26	260	13	or	56	26	700
395	15	or	63	28	339	15	or	63	30	297	15	or	63	30	800

Table Continued from Page 420

445	17	or	71	31	382	17	or	71	34	334	17	or	71	34	900
494	19	or	79	35	424	19	or	79	38	371	19	or	79	38	1,000
988	38	or	158	69	848	38	or	138	75	741	38	or	158	75	2,000
1482	56	or	237	104	1272	56	or	237	112	1112	56	or	237	112	3,000
1975	75	or	315	138	1695	75	or	315	149	1482	75	or	315	149	4,000
2469	93	or	394	173	2119	93	or	394	186	1852	93	or	394	186	5,000

Table 8.—Flues Laid with ½ in. Joints

All joints filled with mortar. Materials and labor for heights in feet Laborer's time includes mortar making. See Table 7 for material needed for cubic feet of mortar. Note.—These tables may be used for almost any one and two flue chimneys, as the variations from these figures would be slight, no matter the size of the flues.

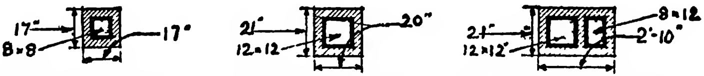


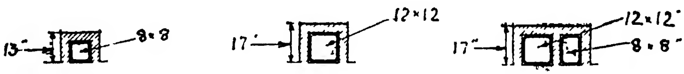
FIG. 4,640 to 4,642.—Various flues laid with ½ in. joints whose properties are given in the accompanying table

Height in Feet	8 x 8 FLUE				12 x 12 FLUE				12 x 12 and 8 x 12 FLUES			
	No of Bricks	Cu ft. of Mortar	Labor-er's Time	Brick-layer's Time	No. of Bricks	Cu ft of Mortar	Labor-er's Time	Brick-layer's Time	No of Bricks	Cu. ft. of Mortar	Labor-er's Time	Brick-layer's Time
1	25 873	.433	.200	.344	34.498	.577	.267	.459	63 895	810	410	718
2	52	1	½	¾	69	1½	½	1	108	2	1	1½
3	78	1½	¾	1	104	2	¾	1¼	162	2½	4¼	2¼
4	104	2	¾	1½	138	2½	1	1¾	216	3½	1¾	3
5	130	2½	1	1¾	173	3	1¼	2¼	270	4½	2	3½
6	156	3	1¼	2	207	3½	1½	2¾	324	5	2½	4¼
7	182	3½	1½	2½	242	4½	1¾	3¼	378	6	3	5
8	207	3½	1½	2¾	276	5	2¼	3¾	432	6½	3¼	5¾
9	233	4	1¾	3	311	5½	2½	4¼	486	7½	3½	6½
10	259	4½	2	3½	345	6	2¾	4½	539	8½	4	7¼
15	389	6½	3	5¼	552	9	4	7	809	12½	6	10¾
20	518	9	4	7	690	12	5½	9¼	1078	16½	8	15
25	647	11	5	8½	863	14½	6¾	11½	1348	21	10	18

List of Brick Walls.

Exterior basement walls........................	12″ solid brick
Exterior 1st and 2nd story walls..........	8″ " "
Interior partitions on dining room side of living room, and corresponding partitions below in basement and above on 2nd floor.	8″ " "
Interior partitions on kitchen side of dining room and corresponding partition below in basement and above on 2nd floor	8″ " "
Veranda piers...	1′ − 8″ " "
Walls between.................	8″ " "
Rear porch piers............................	12″ × 8″ " "

Table 8.—Flues Laid with ½ in. Joints—*Continued*

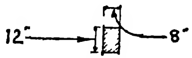


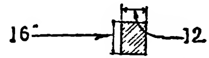
FIGS. 4,643 to 4,645—Various flues laid with ½ in. joints whose properties are given in the accompanying table.

8 x 8 FLUE				12 x 12 FLUE				12 x 12 and 8 x 12 FLUES				Height in Feet
No. of Bricks	Cu ft. of Mortar	Labor-er's Time	Brick-layer's Time	No. of Bricks	Cu ft of Mortar	Labor-er's Time	Brick-layer's Time	No of Bricks	Cu ft. of Mortar	Labor-er's Time	Brick-layer's Time	
17.249	.288	.133	229	23 717	.396	183	316	36 652	613	.283	.488	1
35	1	¼	½	48	1	½	¾	74	1½	½	1	2
52	1	½	¾	72	1½	½	1	110	2	¾	1½	3
69	1½	½	1	95	2	¾	1¼	147	2½	1¼	2	4
87	1½	¾	1¼	119	2	1	1½	184	3½	1½	2½	5
104	2	¾	1½	143	2½	1	1	220	4	1¾	3	6
121	2½	1	1½	166	3	1¼	2¼	257	4½	2	3½	7
138	2½	1	1¾	190	3½	1½	2½	294	5	2¼	4	8
156	3	1¼	2	214	4	1¾	3	330	6	2½	4½	9
173	3	1½	2¼	238	4	1¾	3¼	367	6½	2¾	5	10
259	4½	2	3½	356	6	2¾	4¾	550	9¼	4¼	7¼	15
345	6	2¾	4½	475	8	3¾	6¼	734	12¼	5¾	9¾	20
432	7¼	3½	6	593	10	4½	8	917	15¼	7	12¼	25

Table 9.—Piers Laid with ½ in. Joints.

All joints filled with mortar. Materials and labor for height in feet. Laborer's time includes mortar making. See Table 7 for materials needed for cubic feet of mortar.





FIGS. 4,646 to 4,648—Various piers laid with ½ in joints whose properties are given in the accompanying table.

Height in Feet	8 x 12				12 x 12				12 x 16				Height in Feet
	No Brick	Cu Ft Mortar	Laborer's Time	Bricklayer's Time	No Brick	Cu Ft Mortar	Laborer's Time	Bricklayer's Time	No Brick	Cu Ft Mortar	Laborer's Time	Bricklayer's Time	
1	12 320	209	096	164	18 481	313	143	246	24 641	433	192	328	1
2	25	½	¼	¼	37	⅝	¼	½	50	1	½	¾	2
3	37	¾	¼	½	56	1	½	¾	74	1¼	½	1	3
4	50	1	¼	¾	74	1½	½	1	99	1½	¾	1¼	4
5	62	1¼	½	¾	93	1¾	¾	1¼	124	2¼	1	1¾	5
6	74	1½	½	1	111	2	1	1½	148	2¾	1¼	2	6
7	87	1½	¾	1¼	130	2¼	1	1¾	173	3¼	1½	2¼	7
8	99	1¾	¾	1¼	148	2¾	1¼	2	198	3½	1½	2¾	8
9	111	2	1	1¼	267	3	1¼	2¼	222	4	1¾	3	9
10	124	2¼	1	1¼	185	3¼	1½	2½	247	4½	2	3¼	10
20	247	4	2	3¼	3[illegible]0	6½	3	1½	494	9	4	6½	20

Item Numbers on Estimating Sheet.

1. Length of two sides of house plus width back and front equals 112′–0″. On table No. 1 we find that 2,812 brick are required for a footing 100 ft. long under a 12 in. wall, 282 brick for a 10 ft. length, and 57, for a 2 ft. length. We mark them down in this order opposite item No. 1 on the estimating sheet. In the same way we arrive at the labor and cu. ft. mortar items.

2. Total length footings under 8″ interior partitions = 25 ft. + 15 ft. = 40 ft. Again read totals from table No. 1.

3. Exterior basement walls 12″ thick. Total length (4 sides house) 112′–0″. Height 7′–0″ plus (4″–the level of top of footings below basement floor). Area = 112′–0″×7′–4″=821′–4″. No deductions for openings, as same are each less than 10 sq. ft. Read from table No. 2, putting down results in item 3 on estimating sheet.

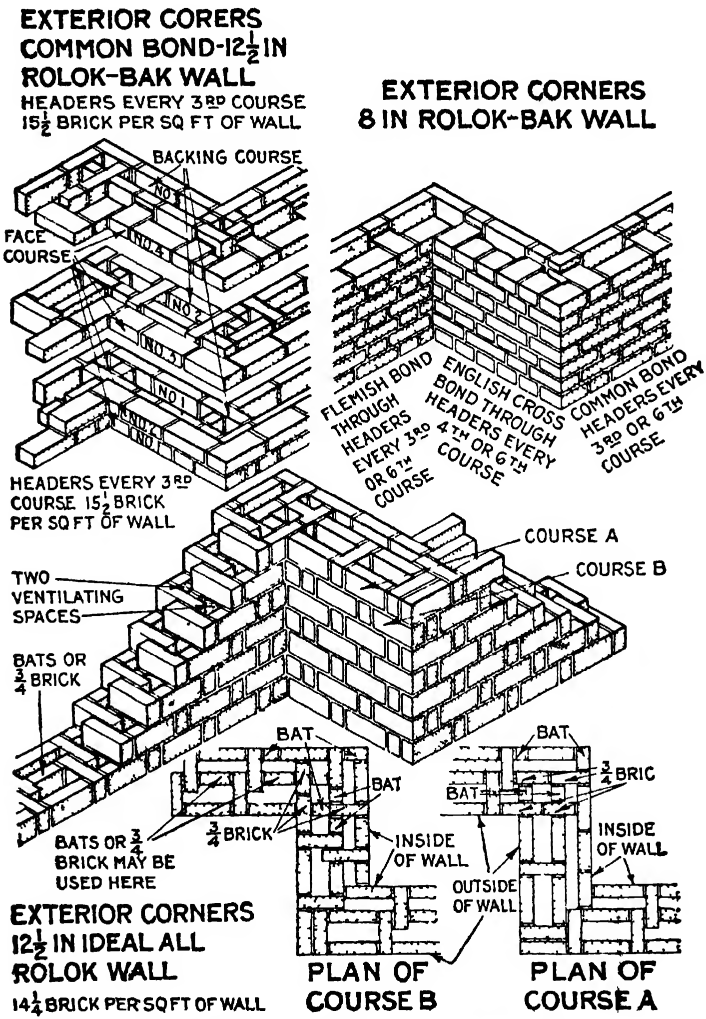


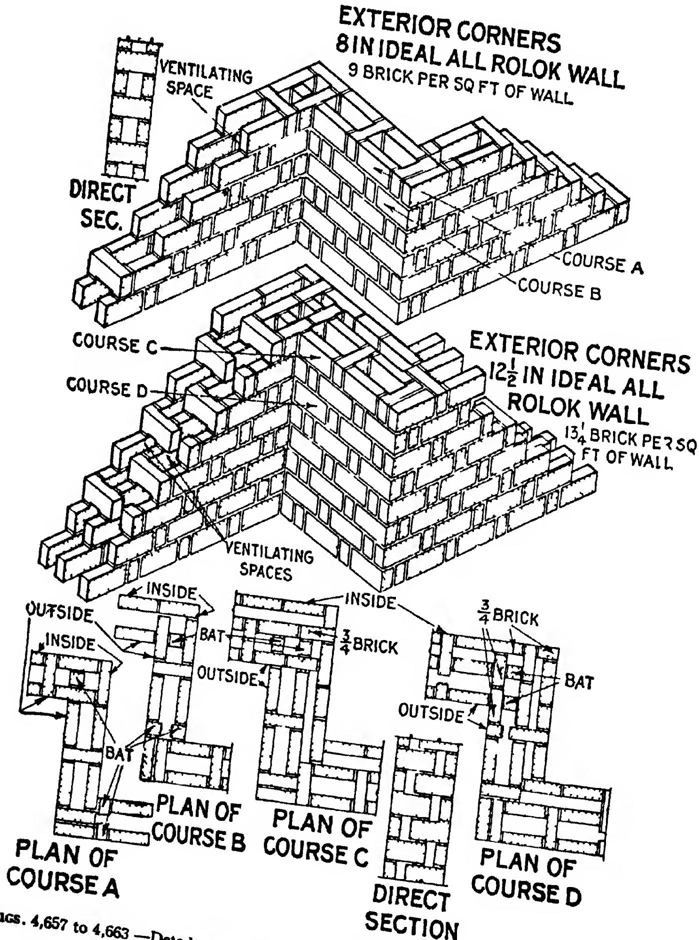
Fig. 4 649 to 4,656 —Details of construction of Ideal all Rolok wall, type 1

4. Interior partitions 8″ thick. Total length 25 ft. + 15 ft. = 40 ft. Height from top of footings (4″ below basement floor) to second floor ceiling = 26′–10″. Area 1,073′–4″ sq. ft. Deduct openings. Three 2′–8×6′–6″ doors in basement. Three 2′–8″×7′–0″ doors; one cased opening 6′–0″×7′–0″ on 1st floor. Three 2′–8″×6′–8″ doors, 3′–0″×7′–0″ opening at stair, and 3′–0″×8′–6″ opening at hall, on second floor. Total deductions for openings 250 sq. ft. Subtracting this from 1,073′ 4″ sq. ft. leaves 823′ 4″ sq. ft. say 825 sq. ft. Read quantities from table No. 5.

Table 10.—Exterior Ideal All-Rolok Walls; 8 in. Wall

Materials and labor for square foot areas. Laborer's time includes mortar making. Cement-lime mortar should be used. See Table 7 for materials needed for cubic feet of mortar. For table of heights by courses see Table 5.

Sq. Ft. area of wall	8-INCH WALL					
	Total No. of Brick including Facing Brick	No. of Facing Brick	Av. Weight in Pounds	Cu. Ft. of Mortar	Laborer's Approx. Time Hours	Bricklayer's Approx. Time Hours
1	9 035	6.023	50 365	080	061	076
10	90	60	504	1	.5	.75
20	181	120	1,007	1½	1	1 5
30	271	181	1,511	2½	2	2 5
40	361	241	2,015	3	2.5	3
50	452	301	2,518	4	3	4
60	542	361	3,022	5	3 5	4 5
70	632	422	3,526	5½	4 5	5 5
80	723	482	4,029	6½	5	6
90	813	542	4,533	7½	5 5	7
100	904	602	5,036	8	6	8
200	1,807	1,205	10,073	16	12	16
300	2,711	1,807	15,109	24	19	23
400	3,614	2,409	20,146	32	25	30
500	4,518	3,012	25,182	40	31	38
600	5,421	3,614	30,219	49	37	46
700	6,325	4,216	35,255	57	43	53
800	7,228	4,819	40,292	65	49	61
900	8,132	5,421	45,328	73	56	68
1,000	9,035	6,024	50,365	81	62	76
2,000	18,071	12,047	100,729	162	124	156
3,000	27,106	18,071	151,094	243	184	228
4,000	36,141	24,094	201,459	324	247	304
5,000	45,176	30,118	251,823	404	309	380
6,000	54,212	36,141	302,188	485	370	457
7,000	63,247	42,165	352,553	566	433	533
8,000	72,282	48,188	402,918	647	495	609
9,000	81,318	54,211	453,282	728	556	685
10,000	90,353	60,235	503,647	809	618	761



Figs. 4,657 to 4,663 —Details of construction of Ideal all-Rolok walls, type 9.

Table 10.—Exterior Ideal All-Rolok Walls—*Continued*

(12½ in. walls)

12½ INCH WALL										
TYPE SHOWN ON PLATE 1				TYPE SHOWN ON PLATE 2				Types Shown on Plates 1 and 2		Sq Ft Area of Wall
Total No of Brick incl. Facing Brick	No of Facing Brick	Av Weight in Pounds	Cu ft of Mortar	Total No of Brick incl Facing Brick	No of Facing Brick	Av. Weight Pounds	Cu ft of Mortar	Laborer's Approx. Time Hours	Bricklayer's Approx. Time Hours	
13.287	5 270	74 022	.118	14 305	6.023	80 229	.132	.090	.111	
133	53	740	1	143	60	802	1½	1	1	.10
266	105	1,480	2½	286	120	1,605	2½	2	2	20
399	158	2,221	3½	429	181	2,407	4	2 5	3 5	30
531	211	2,961	4½	572	241	3,209	5	3 5	4 5	40
664	264	3,701	6	715	301	4,011	6½	4 5	5 5	50
797	316	4,441	7	858	361	4,814	8	5 5	6 5	60
930	369	5,182	8½	1 001	422	5,616	9	6 5	8	70
1,063	422	5,922	9½	1,144	482	6,418	10½	7 5	9	80
1,196	474	6,662	10½	1,288	542	7,221	12	8	10	90
1,329	527	7,402	12	1,431	602	8,023	13	9	11	100
2,657	1,054	14,805	24	2,861	1 204	16,046	26	18	22	200
3,986	1,581	22,207	36	4,292	1 807	24,069	40	27	34	300
5,315	2,108	29,609	47	5,722	2,409	32,092	53	36	45	400
6,644	2,635	37,011	59	7,153	3,012	40,115	66	45	56	500
7,972	3,162	44,414	71	8,584	3 614	48,138	79	55	67	600
9,301	3,689	51,816	83	10,014	4,216	56,160	92	64	78	700
10,630	4,216	59,218	95	11,445	4,819	64,183	107	73	90	800
11,958	4,744	66,621	107	12,875	5,421	72 206	119	82	100	900
13 297	5,271	74,023	119	14,306	6,024	80,229	132	91	112	1,000
26,574	10,541	148,046	237	28,612	12,047	160,458	264	182	224	2,000
39,862	15,811	222,069	356	42,918	18,071	240,688	396	273	336	3,000
53,149	21,082	296,091	474	57,224	24,094	320,917	528	364	448	4,000
66,436	26,353	370,114	593	71,529	30,118	401,146	661	455	559	5,000
79,723	31,624	444,137	711	85,835	36,141	481,375	793	545	671	6,000
93 010	36,894	518,160	830	100,141	42,165	561,604	925	636	783	7,000
106,298	42,165	592 183	949	114,447	48,188	641,834	1,057	727	895	8,000
119,585	47,435	666,206	1 067	128 753	54,212	722,063	1,189	818	1,007	9,000
132,872	52,706	740,228	1,186	143,059	60 235	802,292	1,321	909	1,119	10,000

Table 11.—Exterior Ideal Rolok-Bak Walls; 8 in. Walls

Materials and labor for square foot areas. Laborer's time includes mortar making. Cement-lime mortar should be used. See Table 7 for materials needed for cubic feet of mortar. Table 5 gives height by courses.

Sq. ft. area of wall	8-INCH WALL								
	Flemish headers every 6th course			Flemish headers every 3rd course			Headers every 3rd and every 6th course		
	Total No. of brick incl. facing brick	No. of facing brick	Average weight in pounds	Total no of brick	No. of facing brick	Average weight in pounds	Cu ft. of mortar	Laborer's approx. time Hours	Bricklayer's approx. time Hours
1	10 524	6 502	60 854	10 780	6 844	62 454	116	065	080
10	105	65	609	108	68	625	1	5	75
20	210	130	1,217	216	137	1,249	2 5	1 5	1.5
30	316	195	1,826	323	205	1,874	3 5	2	2 5
40	421	260	2,434	431	274	2,498	4 5	2 5	3
50	526	325	3,043	539	342	3,123	6	3	4
60	631	390	3,651	647	411	3,747	7	4	5
70	737	455	4,260	755	479	4,372	8	4 5	5.5
80	842	520	4,868	862	548	4,996	9 5	5	6.5
90	947	585	5,468	970	616	5,621	10 5	6	7
100	1,052	650	6,085	1,078	684	6,245	12	6 5	8
200	2,105	1,301	12,171	2,156	1,369	12,491	23	13	16
300	3,157	1,951	18,256	3,234	2,053	18,736	35	20	24
400	4,210	2,601	24,342	4,312	2,738	24,982	46	26	32
500	5,262	3,251	30,427	5,390	3,422	31 227	.58	33	40
600	6,314	3,901	36,513	6,468	4,107	37,473	69 5	39	48
700	7,367	4,552	42,598	7,547	4,791	43,718	81	46	56
800	8,419	5,202	48 684	8 625	5,476	49,964	.93	52	64
900	9,472	5,852	54,684	9,703	6,160	56,209	104 5	59	72
1,000	10,524	6,503	60,855	10,781	6,845	62,455	116	65	80
2,000	21,048	13,005	121,709	21,561	13 690	124 909	232	130	160
3,000	31,572	19,508	182,564	32,342	20 535	187 364	349	195	241
4,000	42,096	26,011	543,419	43,123	27 380	249 818	465	261	321
5,000	52,620	32,513	304,273	53,904	34 225	312 273	581	326	401
6,000	63,144	39,016	365,128	64,684	41 070	374,727	697	391	481
7,000	73,668	45,519	425,983	75,465	47,914	437,182	813	456	561
8,000	84,193	52,021	486,837	86,246	54 759	499,636	929	521	641
9,000	94,717	58,524	546,837	97,027	61 604	562,091	1046	586	721
10,000	105,241	65,027	608,547	107 807	68 449	624,545	1162	651	801

5. Brick in exterior walls above basement = length of two sides plus back and front = 112 ft. Total height (from top of basement wall to roof plate) = 19′–6″. Area 2,184 sq. ft. Deduct openings less than 10 sq. ft. area. Three front windows in living room each 3′–2″×4′–10″ (small windows in this room less than 10 sq. ft. Window over stair 2′–10″× 4′–10″. Large dining room windows 6′–2″×4′–10″. Two small dining room windows each 4′–0″×2′–6″. Large kitchen window 2′–10″×4′–10″ (small kitchen window is under 10 sq. ft. in area). Two doors 3′–0″×7′–0″, one door 2′ 10″×7′ 0″. Eight bedroom windows each 3′ 2″×4′ 10″.

Bathroom and stair windows (each under 10 sq. ft.). Total deduction for openings 307′ 8″. Subtracting this from 2,184 sq. ft. = 1,876′ 4″, say 1,880 sq. ft. Read quantities from table 3. (If it were desired to build wall, or any part of it in Flemish, English or English Cross bonds table 4 would in that case be followed.)

Table 12.—Exterior Ideal Rolok-Bak Walls—*Continued*

(12½ in. walls)

12½-INCH WALL							Sq. ft. area of wall
Total no of brick incl facing Brick	Facing brick Flemish headers 6th course	Facing brick Flemish headers 3rd course	Average weight in pounds	Cu ft of mortar	Laborer's approx time Hours	Bricklayer's approx time Hours	
15 443	6 502	6 844	87 634	151	095	117	1
154	65	68	876	1 5	1	1.25	10
309	130	137	1,753	3	2	2 5	20
463	195	205	2,629	4 5	3	3 5	30
618	260	274	3,505	6	4	4 5	40
772	325	342	4 382	7 5	4 5	6	50
927	390	411	5,258	9	5 5	7	60
1 081	455	479	6,134	10 5	6 5	8	70
1 235	520	548	7,011	12	7 5	9 5	80
1.390	585	616	7,887	13 5	8 5	10 5	90
1,544	650	684	8,763	15 0	10	12	100
3,089	1,301	1,369	17,526	30	19	24	200
4,633	1,951	2,053	26,290	45	29	35	300
6,177	2,601	2,738	35,054	60	38	47	400
7,722	3,251	3,422	43,817	76	48	59	500
9,266	3,901	4,107	52,581	91	57	70	600
10,810	4,552	4,791	61,344	106	67	82	700
12,355	5,202	5,476	70,108	121	76	94	800
13,899	5,852	6,160	78,871	136	86	106	900
15,443	6,503	6,845	87,634	151	96	118	1 000
30,887	13,005	13,690	175,269	302	191	235	2,000
46,330	19,508	20,535	262,904	453	287	352	3,000
61,773	26,011	27,390	350,539	605	382	471	4,000
77,222	32,513	34,225	438,174	756	478	588	5,000
92,661	39,016	41,070	525,808	907	574	706	6,000
108,103	45,519	47,914	613,443	1,058	669	824	7,000
123,547	52,021	54,759	701,078	1,209	765	941	8,000
138,990	58,524	61,604	788,713	1,360	860	1,059	9,000
154,433	65,027	68,449	876,347	1,512	956	1,177	10,000

6. Fireplace and flues to first floor ceiling. The exterior wall of chimney is already figured to the roof. Figure to first floor ceiling line, tables covering chimney above that point.

In the basement the chimney is 6′—0″ wide, and figuring from bottom of footings, 8 feet high = 48 sq. ft. wall 16″ thick.

On the first floor chimney is 6 ft. wide and 10 feet high = 60 sq. feet wall 20″ thick = 75 sq. ft. wall 16″ thick. Total including basement 123 sq. ft. wall 16″ thick.

Deduct for ash pit, fire place and flues, Ash pit is 4 ft. wide by 7 ft. high by 1 ft. deep = 28 sq. ft. wall 12″ thick. Furnace flue is 10′—0″ long, fire place flue 7′ 0″ long = 17′—0″ flue 12″×12″, or 17 sq. ft. wall 12″ thick. Total including ash pit = 45 sq. ft. wall 12″ thick = 34 sq. ft. wall 16″ thick. Fireplace is 3′—0″ × 3′—0″ = 9 sq. ft. of wall 20″ thick = 11 sq. ft. 16″ thick. Total deductions 45 sq. ft. wall 16″ thick, leaving 78 sq. ft. say 80 sq. ft. wall 16″ thick in chimney to 1st floor ceiling.

Read table 6 for quantities of brick, mortar, and laborers time, but figure bricklayers time on basis of 1,000 brick per 14 hours (see page 38). Add also 4½ hrs. laborers' time and 12 hours bricklayers' time for building mantel and 4 hrs. bricklayers' time for setting hearth.

7. Flues from 1st floor ceiling line to 2nd floor ceiling line 9′ 6″, say 10′—0″ high, three sides laid lime mortar. Read quantities from flue table 8. (Although tables show one flue 12″×12″ and one 12″×8″, while this chimney contains two 12″ × 12″ flues, there is but little difference between them in material and labor.)

8. Flues above roof in cement mortar 10′—0″ high. Read quantities from table 8.

9. Rear porch piers. Two 8×12 piers each 5′—0″ high (above and below grade) = 12 ft. Read quantities from table 8.

10. Veranda piers. Piers are 7′—6″ high above grade, and extend 3′—6″ below grade. Total height 11′—0″. They are each 2′ 6″ wide with 2′ 6″ return at corners. Total of five 2′—6″ widths plus two 4″ pilasters = 13′—1″ width of wall. Area 144′—10″ say 145 sq. ft. wall 12″ thick in cement-lime mortar. No footing figured. Read quantities from table 6, but increase bricklayers' time to 1,000 bricks per 14 hrs. Piers take longer to build than a straight wall.

11. Cheek walls to steps each project 2′—0″ and are 5 feet high including foundation = 20 sq. ft. wall 12″ thick in cement mortar. No footing figured. Read quantities from table 6.

12. Wall 8″ thick between piers—27′—0″ run. Height above grade

3′ 0″, below grade 3′ 6″. Add the 2″ projection for footing on each side of the wall—total 4″—to the height of the wall. Total height 6′ 10″. Total area 184′ 6″ say 185′ sq. ft. wall 8″ thick. Read quantities from table 6.

13. Cleaning brickwork (front and two sides of house veranda, and brick mantel about 2,500 sq. ft.). Time required 33 hours.

MATERIALS REQUIRED FOR MORTAR

Kind of Mortar	Feet Required	Bbls. Lump Lime	or	Sacks Hydrated Lime	Cu. Yds. of Sand	Bags of Cement
1:3 Cement.........	80 4 84	1½ ⅛	or or	6⅜ ⅜	3 ¼	29¾ 1½
1:1:6: Cement....... —Lime.......	300 40 5 345	8 1 ⅛	or or or	32 4¼ ½	12 1½ ¼	39 5¼ ¾
1:2½ Lime..........	300 90 5 395	17 5 ⅝	or or or	71 21¼ 1¼	12 3⅝ ¼	....
Add two bags cement for cement mortar for sills, chimney, caps, etc., See Specifications, Page 48........	...	....		....	....	2
TOTALS.......	...	25⅛		137	32⅝	78¼

The following quantities of materials would be ordered for this job:

Common Brick.................................63 M.
Lime...26 bbls. (180 lb. bbls.) lump lime, or 137 sacks (50 lb. sacks) hydrated lime.
Sand...33 cu. yds.
Portland Cement..............................20 bbls. (4 sacks to the bbl.)
12″ × 12″ Flue Lining........................60 ft.
Steel Lintels....................................100 lineal ft. 4″ × 3″ × 5/16″ angle 720 lbs.

Labor cost would be:

Laborers' Time.................................512 hours.
Bricklayers' Time..............................453 hours.

ESTIMATING SHEET

Item No.	Feet Required	Number of Brick	Cu. Ft. Cement Mortar	Cu. Ft. Cement-Lime Mortar	Cu. Ft. Lime Mortar	Laborers Time Hours	Bricklayers' Time Hours	NOTES
1	100 10 2 112	2812 282 57	48 5 1	... ...	... ...	22 2¼ ½	20 2 ½	Footings under 12" walls.
2	40	909	15	...	...	7	6½	Footings under 8" walls.
3	800 20 2 822	15,402 386 38	.. .. ..	251 6½ ½	... ...	120 3 ¼	88 2½ ¼	Exterior basement walls.
4	800 20 5 825	10,473 262 65	.. .. ..	... ...	96 2½ ¾	75 2 ½	56 1½ ½	Interior Partitions.
5	1000 800 80 1880	12,706 10,165 1,017	.. .. ..	... ...	135 108 11	93 74 8	84 67 7	Exterior walls above basement.
6	80	1,972	..	...	35	16	28	Fireplace and flues to 1st floor ceiling. Bricklayers' time increased.
			..		..	4½ ...	12 4	Building mantel. Setting hearth.
7	10	330	..	...	6	2½	4½	Flues from 1st floor ceiling to 2nd floor ceiling.
8	10	539	8½	..	...	4	7¼	Chimney above roof.
9	10	124	..	2¾	...	1	1¾	Rear porch piers.
10	100 40 5 145	1849 740 93	.. .. ..	32 13 2	... ...	15 6 1	26 12 1	Veranda piers Bricklayer's time increased.
11	20	370	6½	...	...	3	3	Cheek walls to entrance steps.
12	100 80 5 185	1233 986 62	.. .. ..	20 16 1	... ...	10 7½ ½	9 7½ ½	Veranda walls.
13						33		Cleaning down brickwork.
TOTALS..	..	62,872	84	344¼	394¼	511½	452¼	

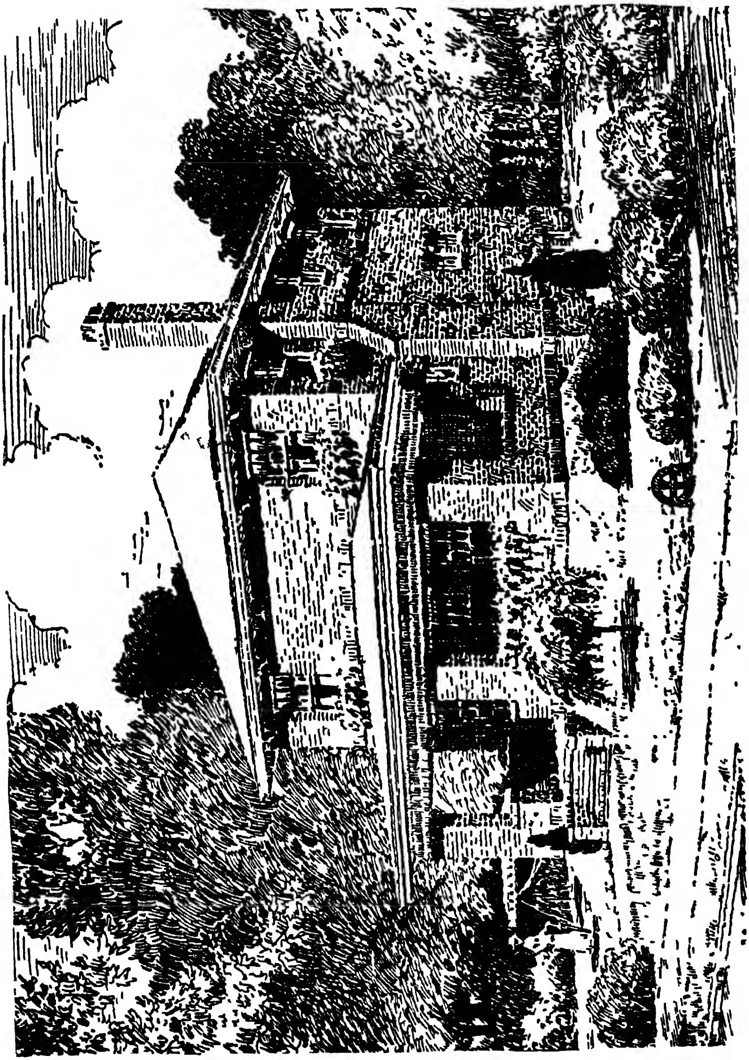
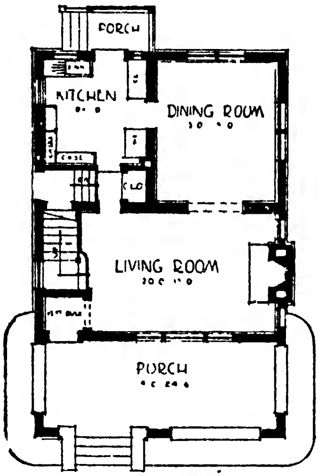


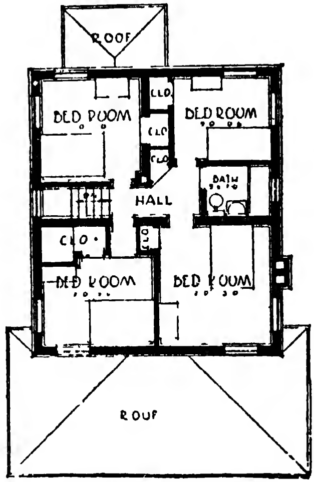
FIG 4,664 —Mohawk design No 15, the house for which the brick required is estimated in the example for estimating brick work

No brick paving is included but can easily be figured from above tables using labor costs as given on page 412.

If mortar color be needed, figure approximately the number of brick on the outside of the wall from the tables, and determine the quantity by the rule on page 36.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

FIGS. 4,665 and 4,666 - First and second floor plans for Mohawk design No. 15.

Quantities with Interior Partitions Omitted

Take out items No. 2 and 4, from estimating sheet. This will also reduce the materials required for mortar. The various items changed would then read as follows:

Common Brick	52 M.
Lime	18 bbls. (180 lb. bbls.); lump lirme 105 sacks hydrated lime.
Sand	29 cu. yds.
Portland Cement	19 bbls.
Laborers' Time	527 hours.
Bricklayers' Time	389 hours.

The remaining items would be unchanged.

CHAPTER 83

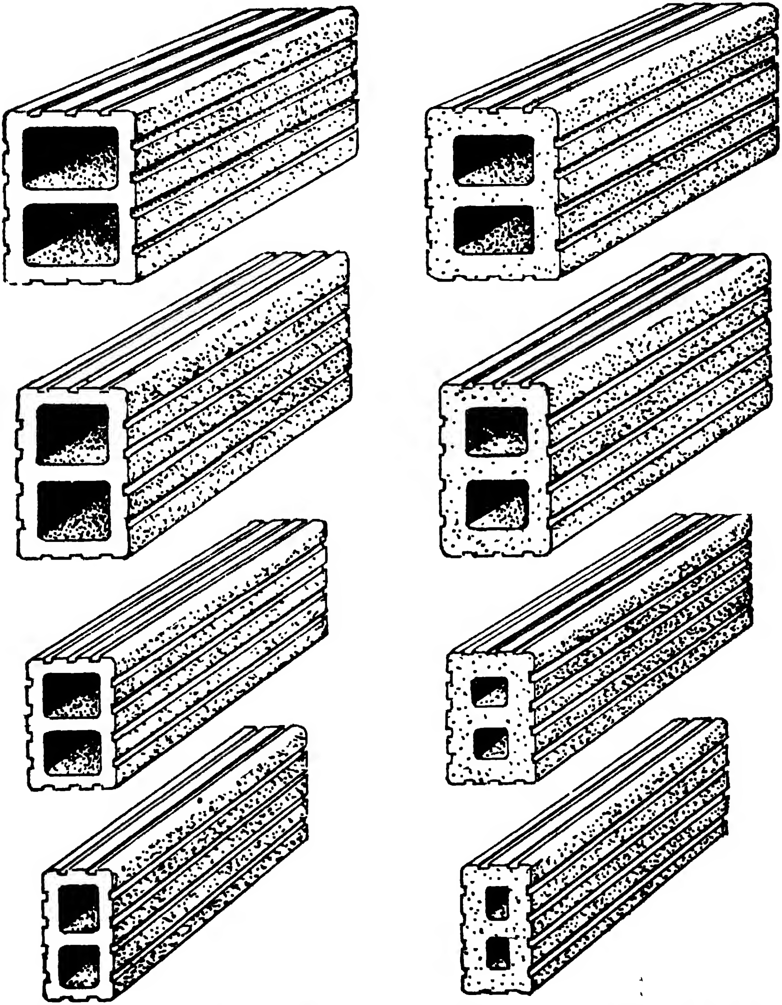
Hollow Tile

By definition, tiling consists of *clay moulded in either solid or hollow shapes and thoroughly burned.* It may be divided into two general classes:

1. Porous terra cotta;
2. Hard or dense tile.

Porous Terra Cotta.—Porous terra cotta is made by mixing the raw clay with sawdust, straw, or other combustible material. When the compound is thoroughly mixed, it is moulded into shapes required and after sufficiently drying, the shapes are placed in a kiln and subjected to an intense heat which consumes all combustibles and leaves the material porous. Porous terra cotta is utilized in many ways especially for fireproofing. It readily admits of nails being driven into it and receives and holds plaster admirably. For arches, partitions, furring, column covering, roof and ceiling tiles it is particularly well adapted.

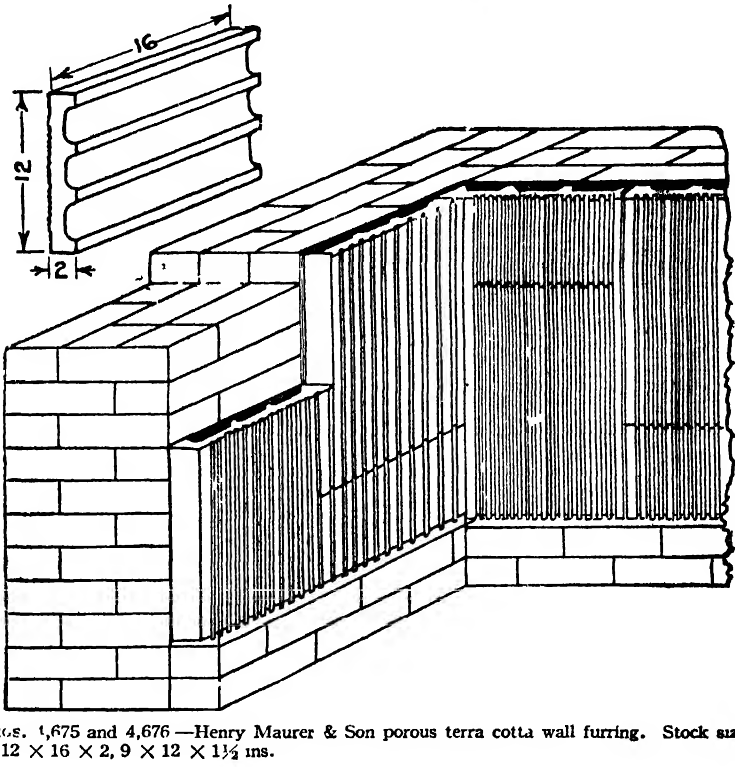
Porous terra cotta when properly made has a compact tough texture and gives out a ringing sound when tapped with a hammer; when made from sandy clay, or from material poorly mixed and burned, shows an uneven soft and crumbly fracture. Hence porous terra cotta should be tested before using. Whenever it has considerable weight to carry as in floor



FIGS. 4,667 to 4,674.—Henry Maurer & Son hollow clay and porous terra cotta shapes for partitions. Stock sizes are. 3 X6 X12; 4 X8 X12; 5 X8 X12; 6 X8 X12; 8 X6 X12 ins.

construction the shell should be at least 1 inch in thickness and the webs or partitions between the cells should be about ¾ in. thick.

Porous Terra Cotta Partitions.—For partition construction porous terra cotta has the advantages of strength combined with lightness; is vermin proof and a good insulator of heat or



Figs. 4,675 and 4,676—Henry Maurer & Son porous terra cotta wall furring. Stock sizes: 12 × 16 × 2, 9 × 12 × 1½ ins.

cold. Being hollow sound is deadened, and dampness does not penetrate.

Figs. 4,667 to 4,674 show different shapes used for partitions. They

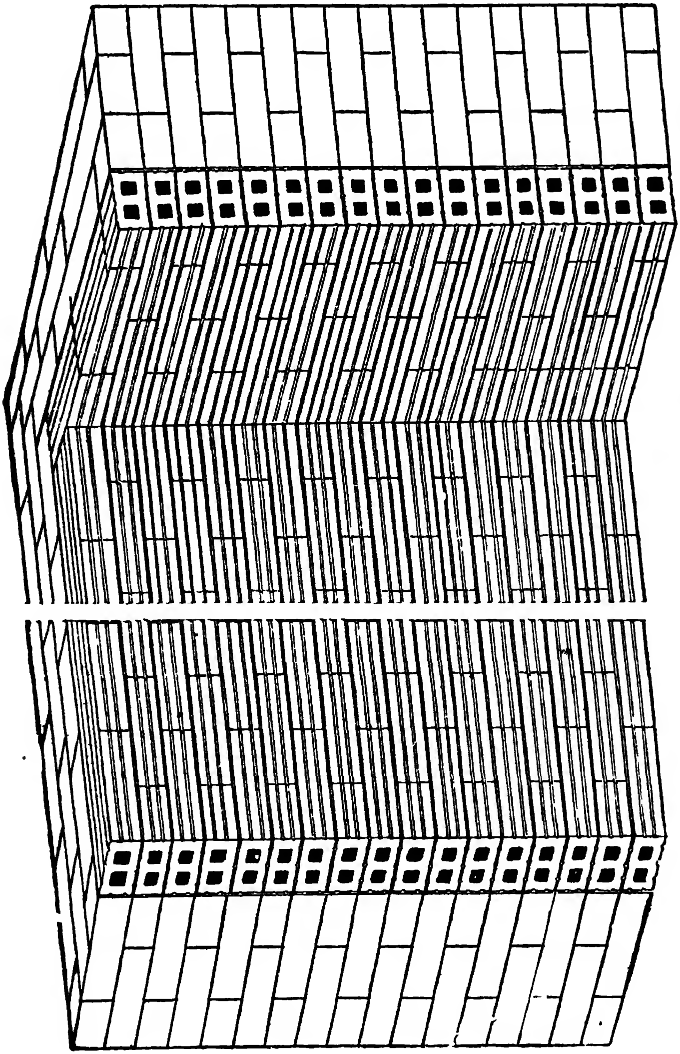
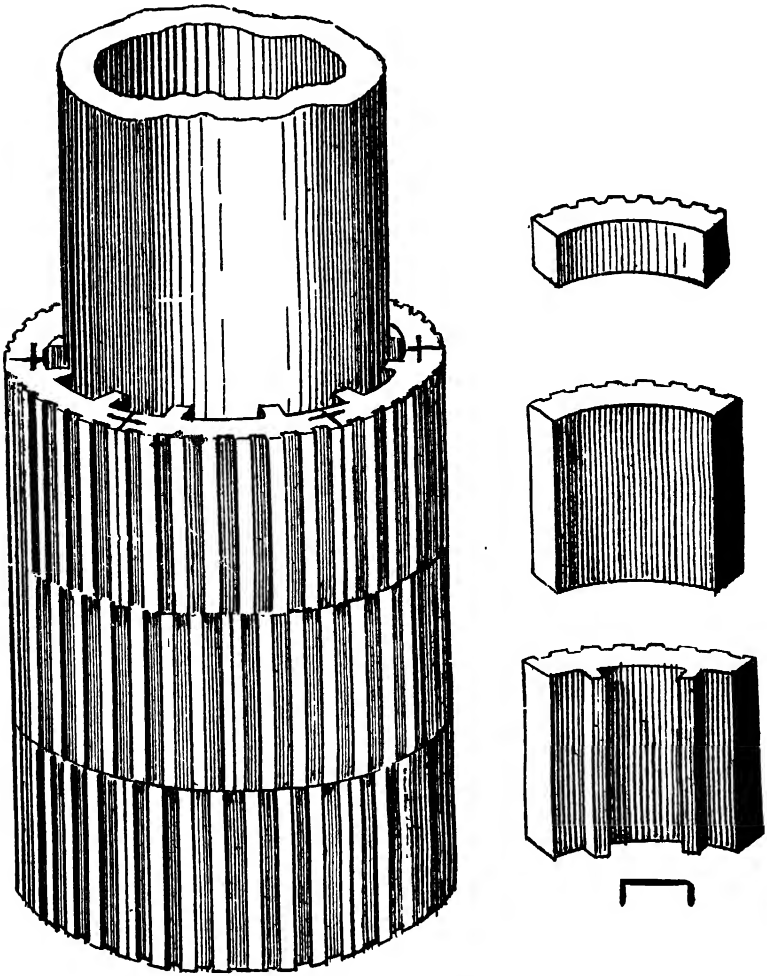
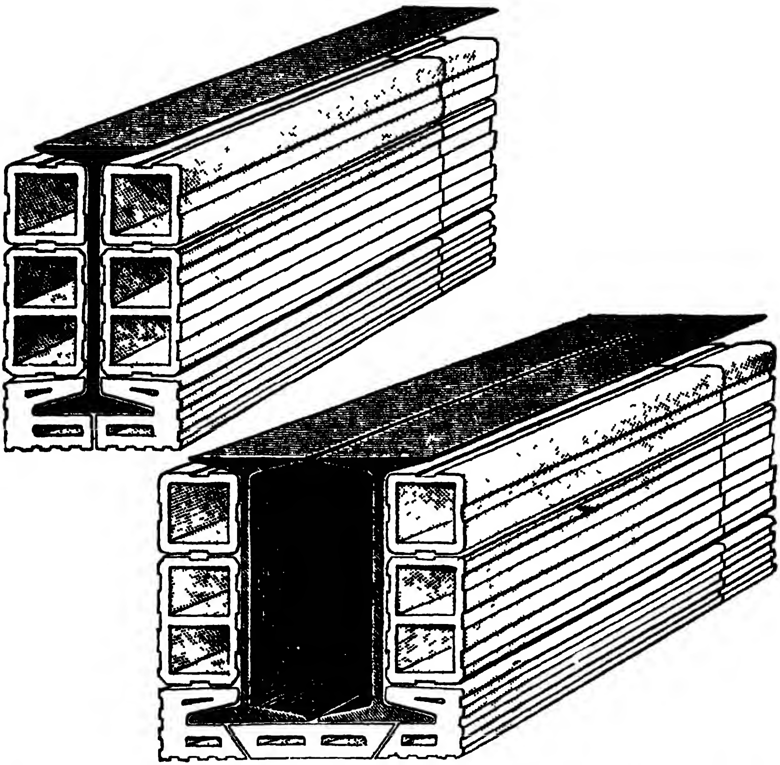


FIG. 4,677.—Henry Maurer & Son porous terra cotta brick ("Haverstraw" size) wall furring. Size $8 \times 3\frac{3}{4} \times 2\frac{1}{4}$ ins. Where headers occur a brick 8×8 is used.



FIGS. 4,678 to 4,682.—Maurer fire proofing for iron columns and detail of the tile and tie pieces. The necessity of protecting all structural metal exposed to heat is due to the fact that steel or iron when exposed to temperatures from 1200 to 1325° Fahr., becomes red hot and bends.

are self supporting. Being larger than brick, they can be placed in position by any bricklayer in less time than is required to lay brick. The plaster is applied directly to the blocks, which as shown are dovetailed on the surface to allow the plaster a firm hold. Since the porous terra cotta will take nails, baseboards and wainscoting are easily secured.



FIGS. 4,683 and 4,684 —Maurer hollow tile fire proofing for single and double girders. Gauged mortar is used for holding the tile to the girders, any width girder can be covered by increasing the bottom (center) piece.

Porous Terra Cotta Furring.—An important factor in fireproofing is the protection of the outside or bearing walls. The

adaptation of porous terra cotta for this purpose and mode of construction is shown in figs. 4,675 and 4,676. The hollow ducts prevent the penetration of dampness by giving a circulation of air between the wall and furring. It also dispenses with the use of lath as plaster can be applied directly to the blocks. They are secured to the wall by setting them in gauged mortar, also by the use of flat headed nails driven into the joints of the brickwork at intervals.

Fig. 4,702 shows porous terra cotta hollow brick used where nailing is necessary for wainscoting, chair rail, and picture moulding.

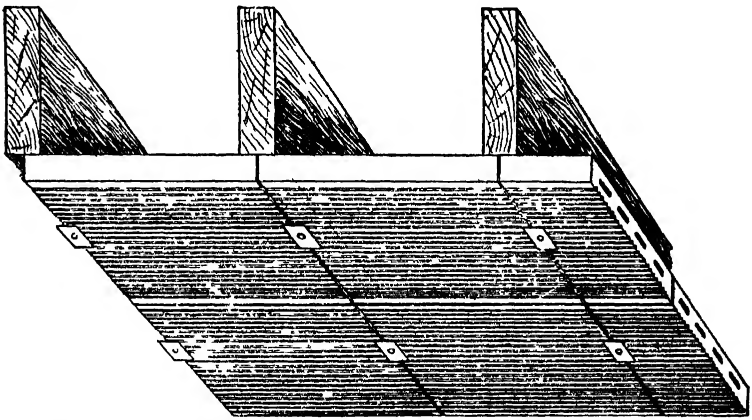


FIG. 4,685 —Henry Maurer & Son porous terra cotta tiles for fire protection of wooden joists Size. 12×16×2.

Porous Terra Cotta Tiles for Beam Protection.– Building laws in many localities require the fireproofing of wooden joists where there is extra fire hazard as over bakers' ovens, etc. The method shown in fig. 4,685 is simple and complies with the law. The blocks are fastened to the underside of the joists by means of iron washers as shown, made sufficiently large to catch the center of two blocks at end. A wire nail is

then driven through the washer into the joist, or a screw can be used, thus firmly securing the blocks in position.

Hard or Dense Tiling.—This kind of tiling is stronger than the porous terra cotta tiling, but is more brittle, and is made

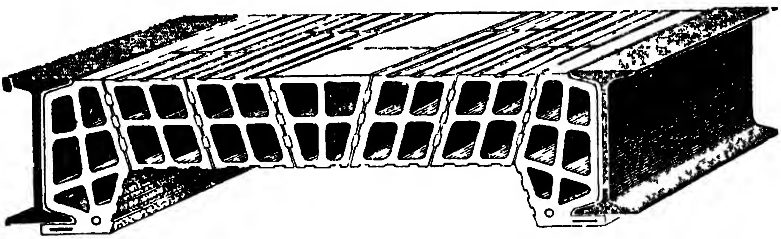


FIG. 4,686.—Hollow tile for flat arches supported or raised skew backs for roofs, etc. This style arch is generally used in cases where beams are deep and no flat finish is required. It will be found useful in connection with flat roofs, thereby saving expense and weight both in beams and brick.

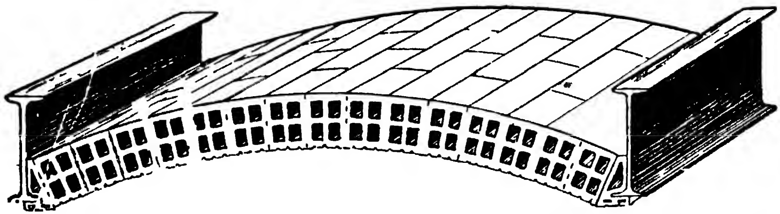
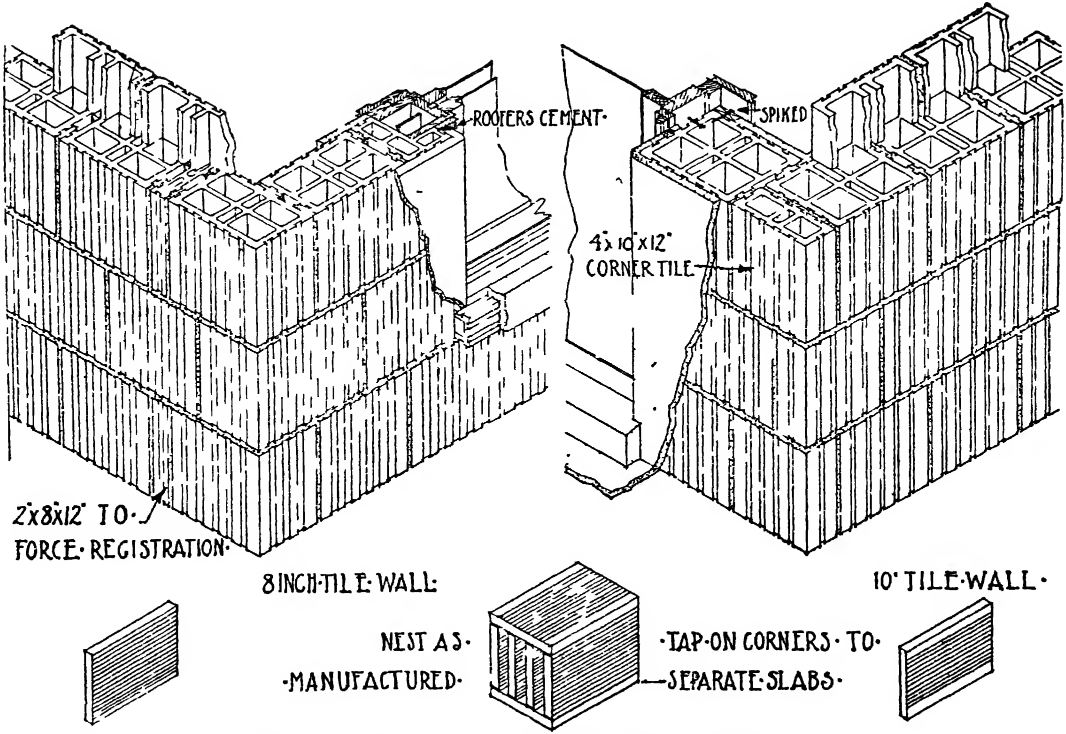


FIG. 4,687.—Hollow tile segmental arch for spans from 10 to 15 ft. between iron beams, depth of arch 6 and 8 ins.

of fire clay combined with either potter's plastic, or tough brick clays, moulded into shapes to suit various constructional purposes. While the clay is still in a moist condition, it is subjected to heavy pressure, which makes it very dense, and gives the finished material great crushing strength. The tiles are then dried and burned in a kiln.

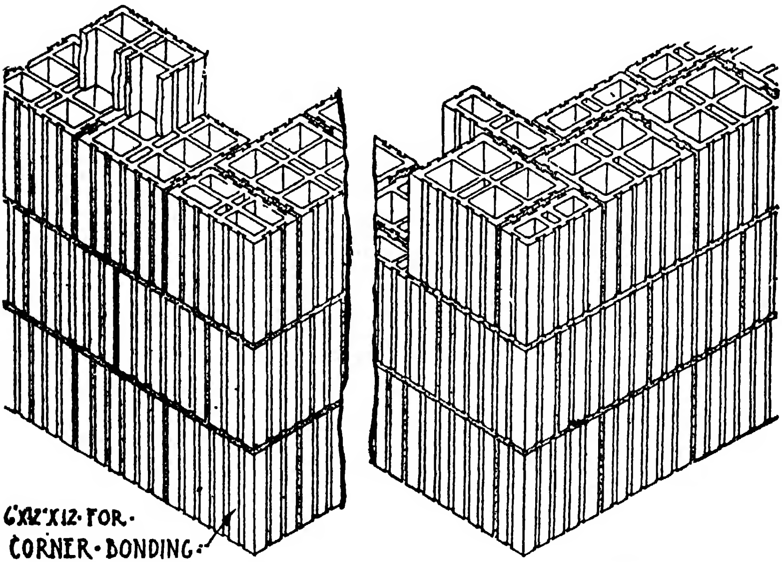


FIGS 4,688 to 4,692.—Natco scored tile 8 and 10 in wall construction and detail of shapes.

There are several grades known as:

1. Very hard burned or vitreous;

Includes those tiles with less than 8% absorption. ***Adaptation:*** foundations; exterior unstuccoed walls or other uses where resistance to moisture is the prime consideration. This grade is harder than is considered advisable for stuccoed or veneered walls.



Figs. 4,693 and 4,694.—Natco scored tile 12 and 14 in. scored tile wall construction.

2. Standard hard burned;

Includes those tiles having not over 12% absorption which is standard specification for load bearing exterior walls and such similar work where they are to be stuccoed or veneered with brick or other covering.

3. Ordinary or medium burned.

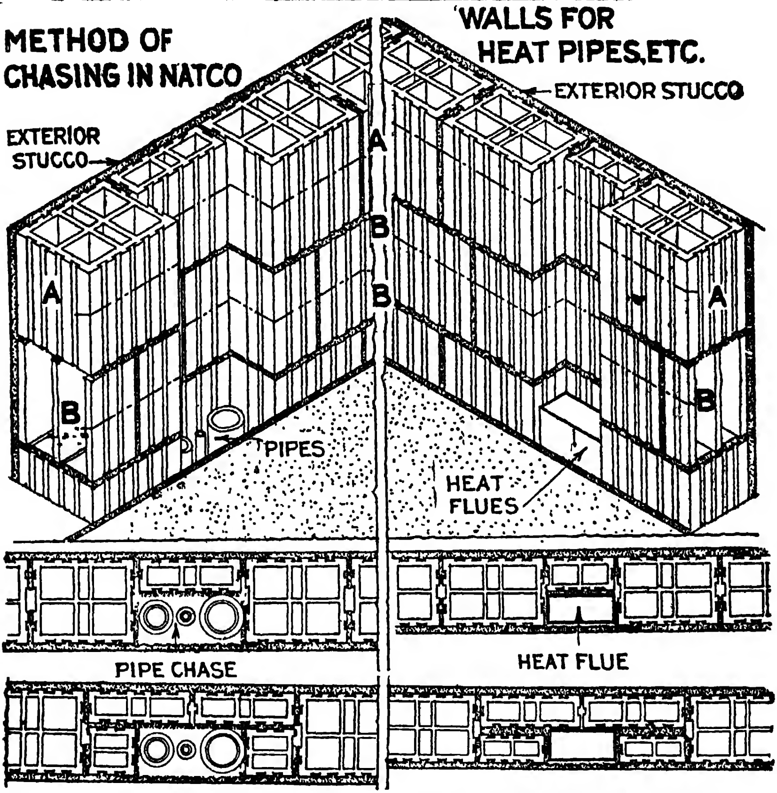
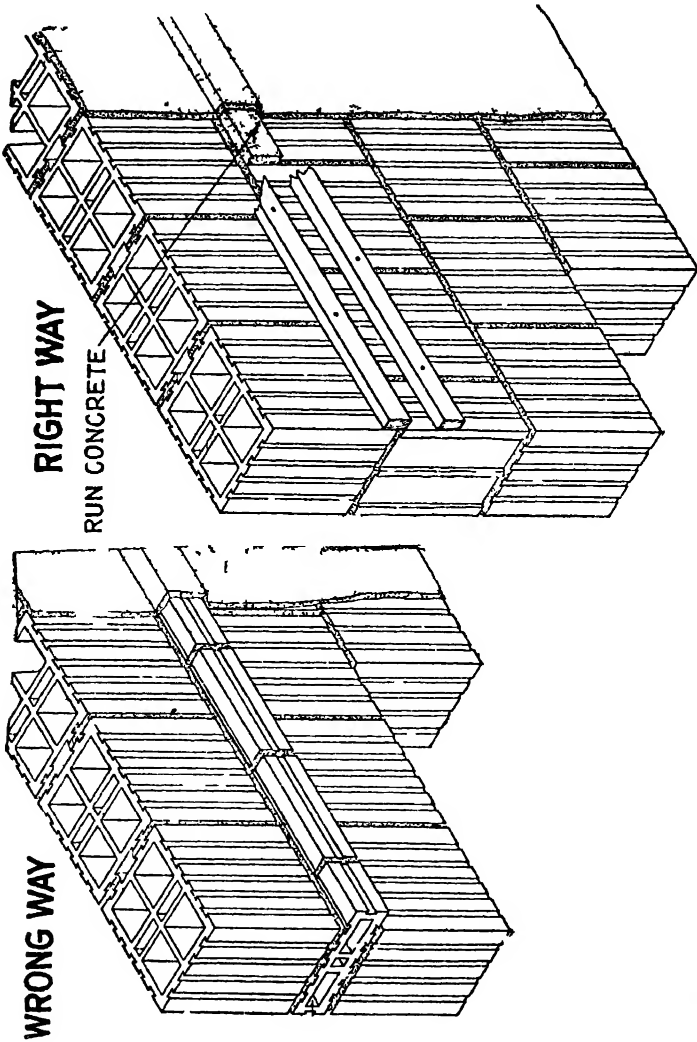


FIG. 4,695.—Natco scored tile 10 in. wall with stucco exterior finish, showing 6×12 chase for pipes.

FIG. 4,700.—Natco scored tile 8 in. wall with stucco exterior finish showing 4×9 chase for heat pipes.

NOTE.—***Disadvantages of tile floor arches.*** The principal disadvantage of tile arches for floor construction is the difficulty of adapting any system to the filling of irregular shaped spaces. The arches must be set between I beam or channels, and to get the best effect the supporting beams must be parallel or nearly so. Tile arches, especially of the end constructions, are weakened more by holes for pipes than are the monolithic floors. As there is no bond between the rows of tiles in the end construction arch, if a single tile in a row be cut out or omitted, there is nothing to hold up the remaining tiles in the row except the adhesion of the mortar in the side joints. In this respect side method arches have an advantage over the end construction. Where it is necessary to use considerable concrete filling over the arch the weight of the floor construction will usually greatly exceed that of the concrete systems, and this additional weight means, also, additional expense. The floor blocks are liable to breakage and chipped blocks in the floor are not unusual



FIGS 4,701 and 4 702 —Wrong and right way to run water table on Natco scored wall tile.

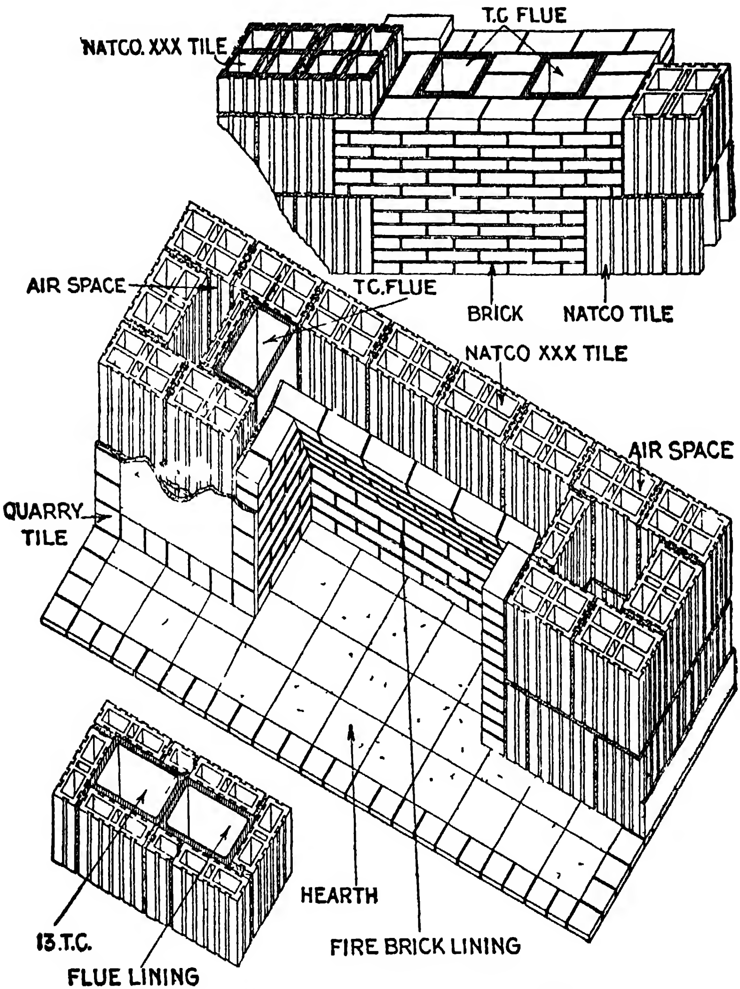
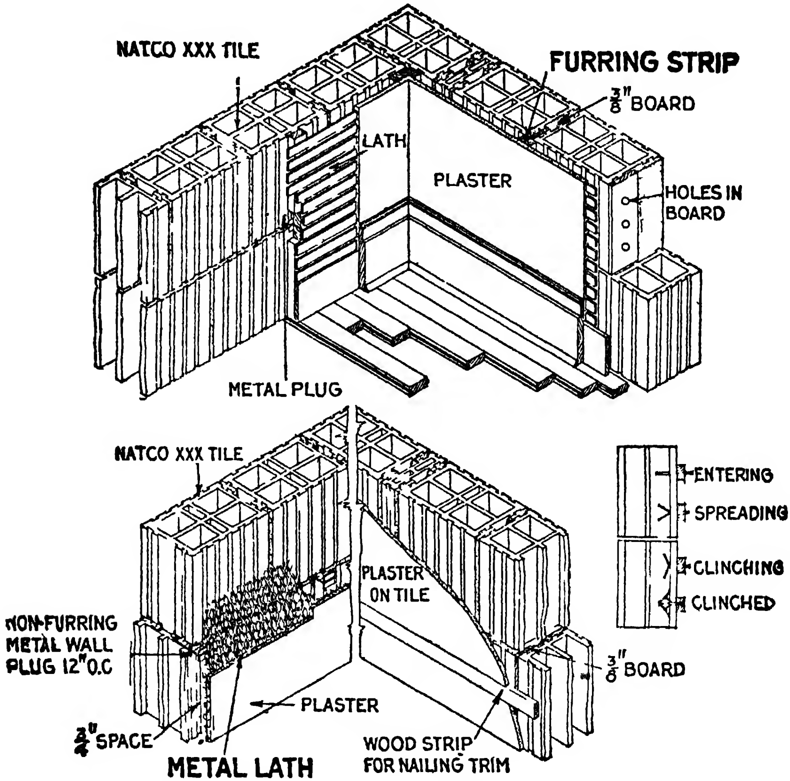


FIG. 4,703.—Method of bonding brick pier or chimney in Natco scored tile walls.

FIG. 4,704 and 4,705 —Fireplace construction with Natco scored hollow tile, brick and stucco veneer, and detail of scored hollow tile around flue lining



FIGS 4,706 and 4,707 —Method of fastening furring strips, lath and plaster to Natco scored hollow tile

FIGS 4,708 to 4,709 —Method of securing metal lath to Natco scored hollow tile, and usual method of plastering directly on tile with detail showing self clinching nail used for nailing into tile

NOTE —In present day estimating all openings containing 10 square feet or more are deducted in full, so that the estimate will show just as nearly as possible the actual number of common brick required to complete the job The old method of estimating corners, angles, chimney breasts, etc , by doubling the quantity of brick actually required is no longer used by experienced builders, but is only used by those who depend upon obsolete data for their guide and by those whose business is not of sufficient volume or importance to require actual quantities and costs

Includes all tile manufactured for fire proofing, having an absorption value greater than 12%, and a perceptible "ring" when struck.

Single Shell Wall Tile.—For small and moderate sized buildings where the walls are not subjected to heavy loads the

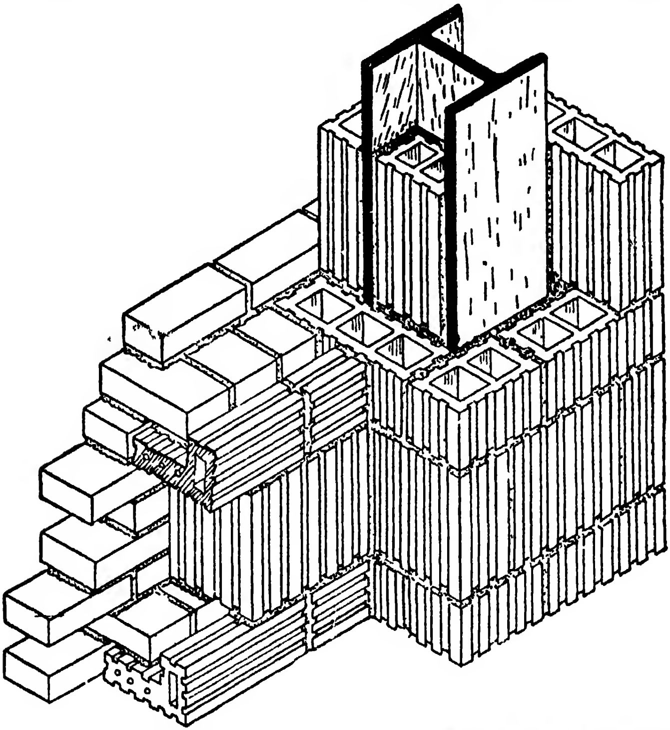
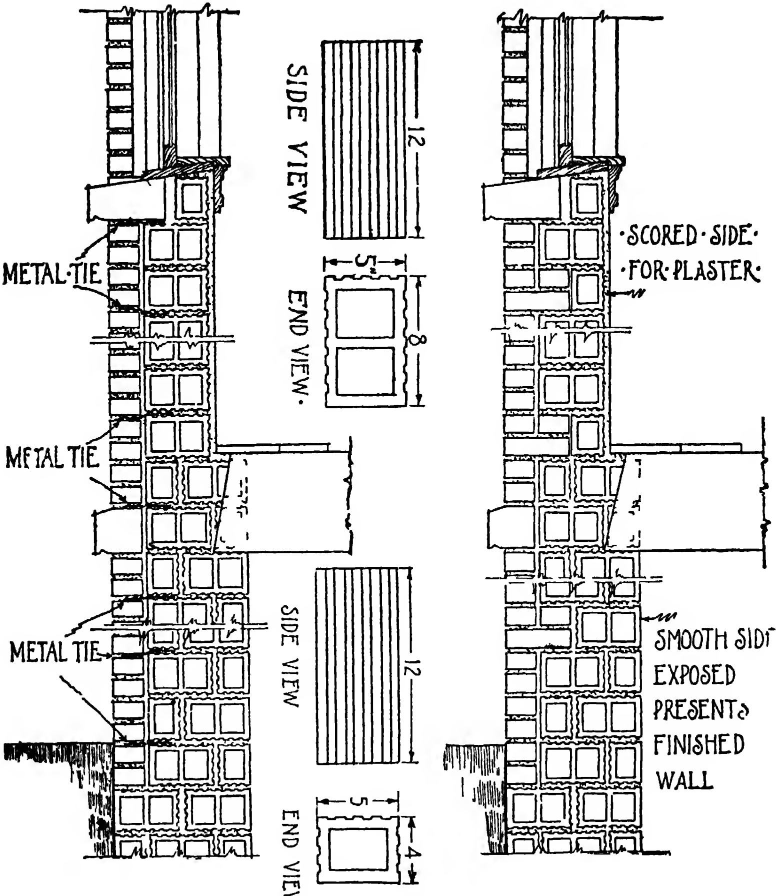


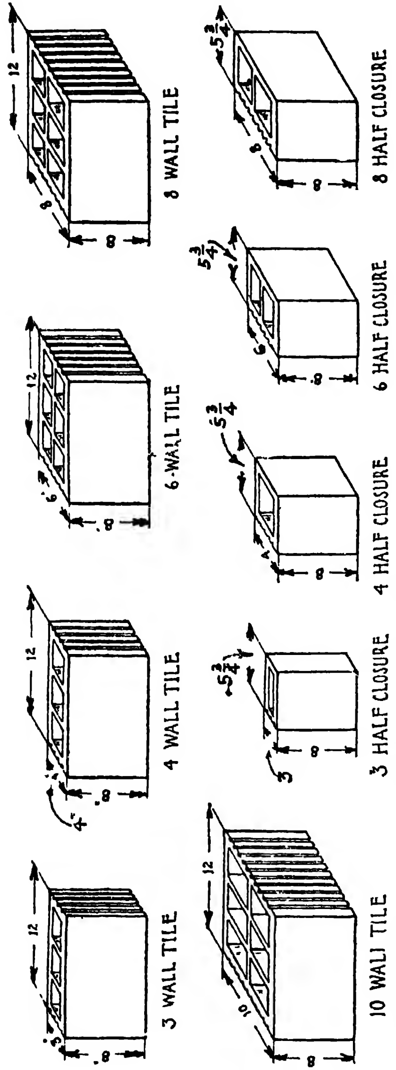
Fig. 4,710.—Covering of steel column at corner with Natco scored hollow tile, brick veneer.

tiles of this class are used. There are as with brick a multiplicity of shapes.

Figs. 4,717 to 4,734 show shapes of single shell smooth wall tiles, and figs. 4,735 to 4,756 scored wall tile. Where the side of the tile forms an exterior finish the smooth type is used as



FIGS 4,711 to 4,716 —Natco ' Bakup type tile wall construction with brick veneer This type tile (4 × 5 × 12) is scored on three sides and smooth on one 5 × 12 face so that a smooth wall inside or out may be had if desired Fig 4 711 shows brick veneer secured with metal ties, figs. 4,712 and 4,713, side and end view of small tile, figs 4,714 and 4,715, side and end view of large tile, fig 4 716, brick veneer bonded to tile with brick headers, and arrangement of tile for plaster, or smooth side interior finish



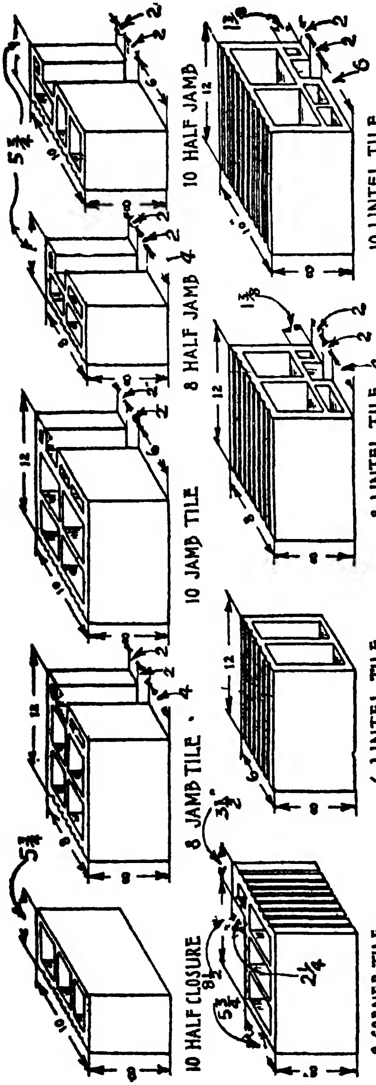
Figs. 4,717 to 4,725.—Various Natco *single shell* wall tiles.

shown in figs. 4,757 to 4,760. The scored type blocks find a variety of uses as with exterior stucco, interior plaster finish, brick veneer, etc., as shown in the accompanying illustrations.

Double Shell Wall Tile.—As indicated by the name, the interior and exterior bed or horizontal mortar joints are spread on double shells of sufficient width to insure a well bonded wall of maximum strength.

The head or vertical joints are spread on the edges of the ends of each tile so as to leave an air space in these joints. The recess or moisture stop at both ends of the regular wall tile further assures the obtaining of this air space.

No attempt should be made to spread mortar on the cross webs. Strict adherence to these details



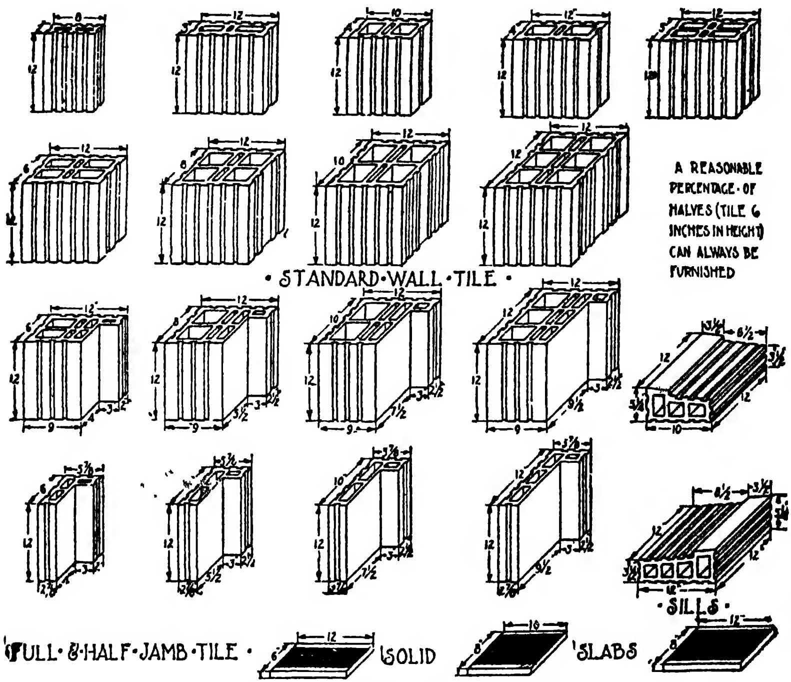
FIGS. 4,726 to 4,734.—Various Natco single shell wall tiles.—*Continued.*

will avoid through mortar joints which are almost invariably conductors of moisture and cold.

Fig. 4,761 shows an 8 in. double shell tile and fig. 4,762 a typical wall section. A $6\times 12\times 5$ tile is used for 6 in. walls, and an $8\times 12\times 5$ tile for 8 in. walls.

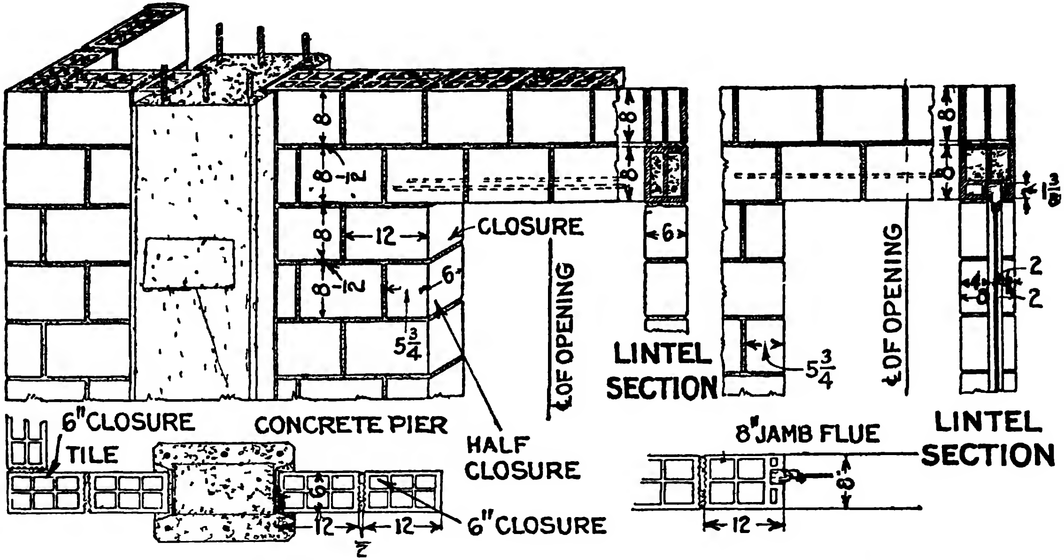
The various shapes of double shell tile are shown in figs. 4,763 to 4,778.

In designing buildings or when laying out foundations to other walls, it should be borne in mind that this face tile is made in 12 and 5¾ in. lengths, and the length of the walls from corner to corner and the width of all openings, should conform to these full and half units, allowing ⅜ in. for mortar joints.



FIGS. 4,735 to 4,756.—Various Natco single shell scored (XXX) wall tile.

NOTE—*Hollow tile don't's:* 1. Don't have the hollow tile dumped from a truck, but have each size of tile stacked by itself. This will save time and money when masons are ready for tile, besides doing away with breakage. 2. Don't patch up the job with brick. Hollow tile are made in proper shapes and sizes; it is therefore very seldom necessary to use brick. 3. Don't use too much lime in the mortar, it weakens the mortar. 4. Don't fail to cover up the top course of tile in wall at quitting time. This protects the work and prevents the filling of cells with rain or snow. 5. Don't leave any holes or crevices on the outside or inside of the wall. Be sure all joints are well sealed. Above all, don't depend upon the stucco to fill up the mortar joints. 6. Don't allow the masons to break up a lot of tile when they require small pieces. 7. Don't use the nest of 1 in. slabs as full tile. They should be broken apart and single slabs used for bearing under joists, for working up to the story heights, sills, etc. 8. Don't cut holes into the tile in which to frame the joists, but use the facing tile at ends of beams, and other tile between beams. Remember that the strength of the wall depends upon thorough bearing of webs and shells, and every hole weakens the wall, and is the easiest way for dampness to penetrate. 9. Don't forget to put proper drips on the underside of the sills. This is very important. 10. Don't use special arch lintels for spans wider than 5 ft. Don't forget that all wooden frame work will shrink; therefore special care should be taken to thoroughly calk between all wood work and hollow tile. 11. Don't forget to use a good waterproofing compound in the finish coat of stucco, if the house be situated in a position exposed to driving storms. 12. Don't try to apply stucco during freezing weather. 13. Don't guess where the various sizes of tile are to be used.



FIGS 4,757 to 4,760 —Natco single shell smooth tile wall construction Figs 4,757 and 4,758, plan and elevation of 6 in curtain wall between concrete piers, figs 4,759 and 4 760, plan and elevation of window opening with steel sash.

The height of walls and of all openings should be fixed in multiples of 5 ins allowing ⅜ in. for each *bed* mortar joint The shapes shown in the accompanying illustrations are standard and architects or engineers should avoid any "specials," because the preparation of a new die takes considerable time and money and involves the manufacture of an untried shape

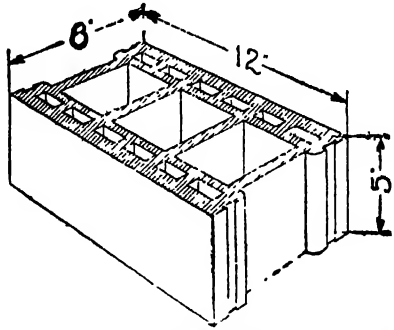


FIG. 4,761.—Natco 8 in. double shell tile. ***Types, glazed:*** One scratched face 12 × 5, and one smooth face 12 × 5, giving an exterior finish similar to a rough face brick and a smooth impervious interior. *Unglazed*: Two scratched faces 12 × 5, giving a choice of two faces for an exterior finished surface similar to a rough face brick and an interior scratched surface rough enough for the application of ordinary plaster directly to the hollow tile surface.

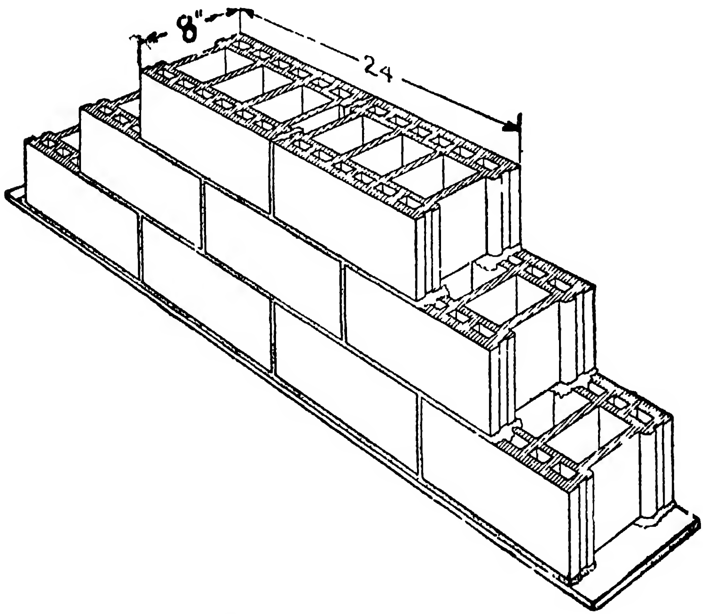
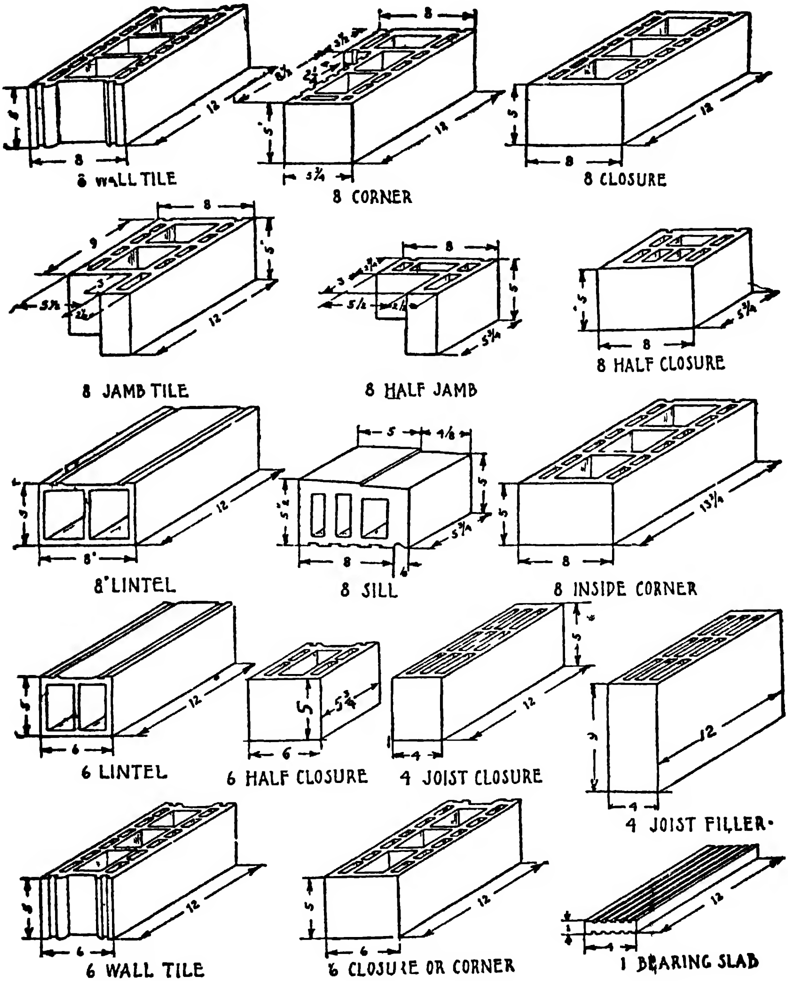
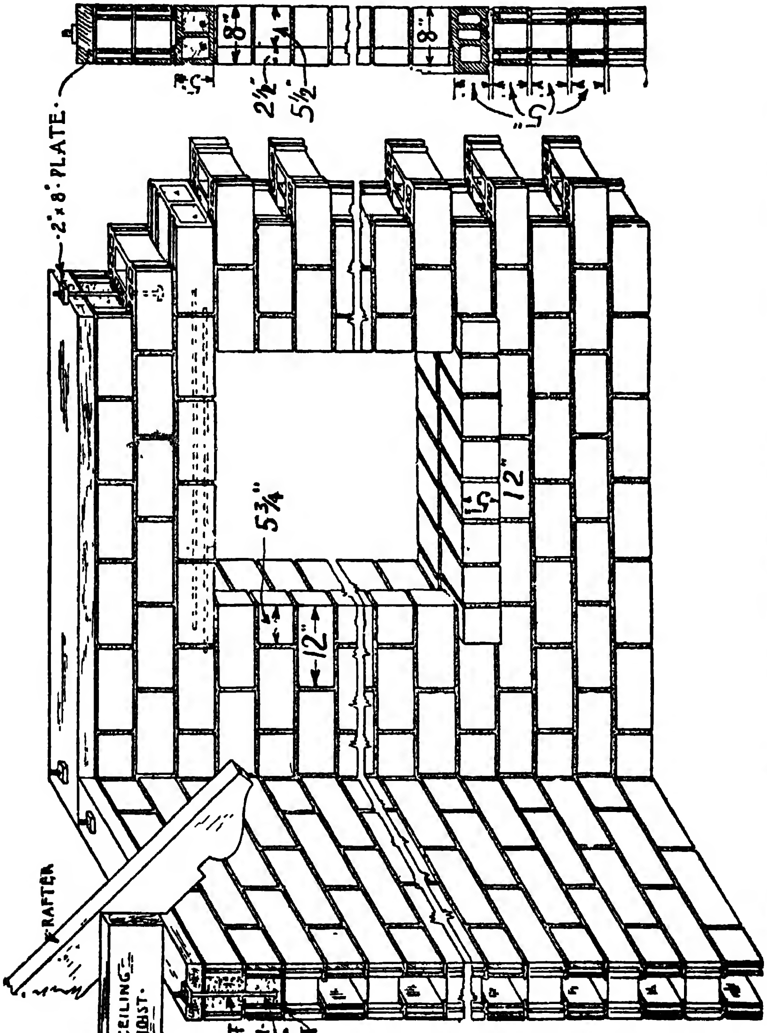


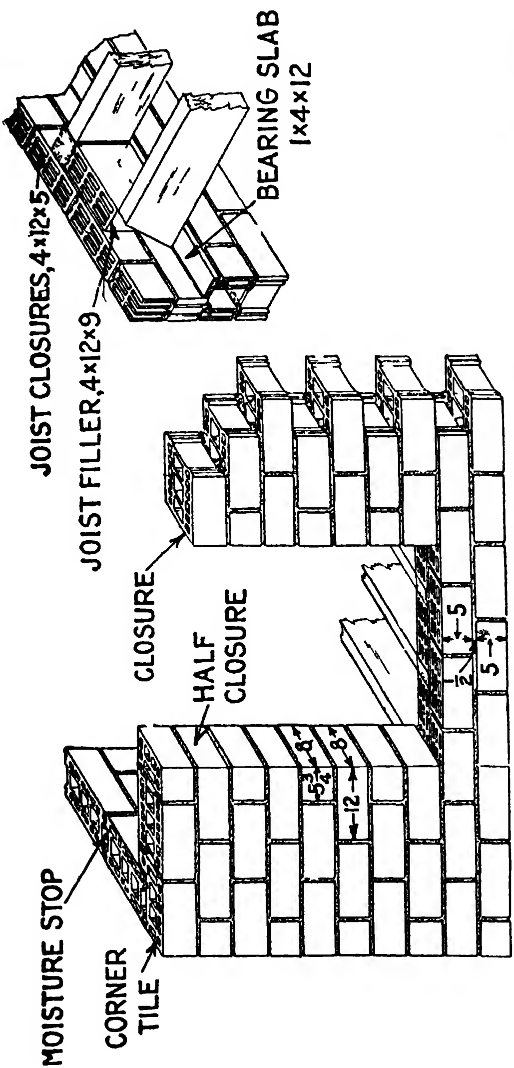
FIG. 4,762.—Natco 8 in. double shell wall.



FIGS. 4,763 to 4,778 —Various shapes of Natco 6 and 8 in *double shell* tile.



FIGS. 4,779 and 4,780.—Natco 8 in. wall construction with double shell tile showing method of anchoring roofing plate.



FIGS. 4,781 and 4,782 —Natco 8 in wall construction with double shell tile showing door opening, external angle and bearing construction

These *standards* have been adopted after long experience and investigation and should meet every building requirement.

The following table shows the strength of double shell tile:

*Strength of Double Shell Tile.

Number of Specimen	Nominal Size	Net Area (Sq. In)	Maximum Load Total (Lbs.)	Units (Lbs per Sq. In.)
1	8'' x 12'' x 5''	44 25	299450	6770
2	8'' x 12'' x 5''	44 25	258580	5840
3	8'' x 12'' x 5''	44 25	285280	6450
4	6'' x 12'' x 5''	39.75	238000	5990
5	6'' x 12'' x 5''	39.75	311650	7840
6	6'' x 12'' x 5'	39.75	270510	6810
7	8'' x 12'' x 5''	44.25	224760	5080
8	6'' x 12'' x 5''	39 75	252050	6340

NOTE:—Specimens No. 7 and No. 8 were glazed. Specimen No. 7 showed a detail failure at one and due likely to improper bedding which no doubt explains the low result obtained.

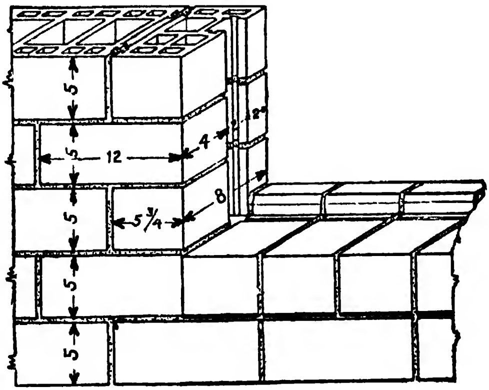


FIG. 4,783.—Natco double shell tile for steel sash; detail showing jamb.

*NOTE.—These tests were made on Natco tile by Carnegie Institute of Technology, Pittsburg, Pa., July, 1918. Specimens 7 and 8 were glazed. Specimen 7 showed a detail failure at one end due likely to improper bedding, which no doubt explains the ow result obtained. All tile were tested on end and were bedded in plaster of Paris on top and bottom, the plaster of Paris cap extending over the webs so that the full cross section of the tile was in bearing. The unit loads were bared on the net area.

Clay Roofing Tiles.—These tiles are made of hard burnt clay and are used on pitched and Mansard roofs. They are held on the iron or wooden rafters by projections on inside of tile so formed as to take hold of rafter, besides one overlapping the other, and also by means of wire fastened to rafter on lower part of tiles, their own weight holding them in position. Advantages of this form of roofing are durability, fire proof, and insulator of heat or cold.

CHAPTER 84

Tiles

The origin of the word *tile* is in the Anglo-Saxon *tigel* which is a derivative of the Latin *tegula* from *tego*, meaning to cover. Although since appropriated to designate other products made in all sorts of shapes and from all kinds of raw materials, the term *tile* unqualified still properly applies to those examples of the ceramic art which are used as a surfacing or finish for floors, walls, ceilings, for decorative and sanitary purposes on the interior and exterior of buildings.

Tile as further defined, is *a plate of thin baked clay used for covering floors and roofs, for making drains and for decorative effects.*

Classification of Tiles.—The several names under which tiles are known are largely trade descriptions, although some designations have significance. Accordingly tile may be classed as:

1. Encaustic.
2. Semi-vitreous.
3. Unglazed vitreous.
4. Bright glazed.
5. White glazed.
6. Bright colored enameled.
7. Matt glaze.
8. Faience.
9. Quarries.
10. Ceramic mosaic.

Encaustic Tiles.—The word encaustic signifies that the tiles referred to are neither roof nor drain tiles. The word itself means

"*painted* and having the colors fixed by heat." Encaustic tiles as manufacturers classify them, are described as unglazed semi-vitreous, unglazed vitreous, bright glazed, colored enamels, matt or dull glaze, faience, and flint.

Semi-Vitreous Tiles.—These are unglazed tiles made of natural clays with, in some instances, stains added to get color, and that do not or will not permit of high enough heat to flux a vitreous ingredient. These are the commonest kind of tiles made, and the colors are confined to red, buff, chocolate, drab, salmon, and black. Some of the above colors will admit of a certain amount of vitrification, but it is not generally done.

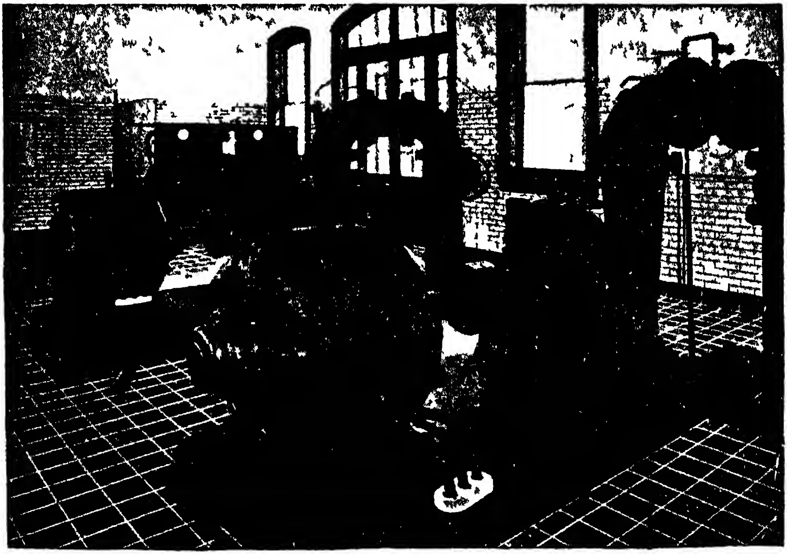


FIG 4 784 —Tiling for pumping station One of the first things necessary in a pumping station is cleanliness especially in the filter rooms Lined with tiles, the floors walls and ceilings of these important rooms offer no lodging place for dirt dust germs or other impurities and can be quickly and easily washed down with the ordinary hose Tiling can even be sterilized if necessary for live steam has no harmful effect on it.

Unglazed Vitreous Tiles.—In making these tiles white clays are largely used with the addition of vitrifying ingredients that flux on firing and cause vitrification. The colors are obtained with chemicals or stains and are produced in the following colors: white, cream grays, celadon, sage, blue, green, olive, and pink. By an examination of the colors you can easily distinguish the semi-vitreous from the vitreous. There are, of course, some exceptions as described above in semi-vitreous.

Bright Glazed Tiles.—A bright glaze finish is secured by dipping any of the above mentioned tiles in white transparent glaze that does not change the colors of the tiles.

White Glazed Tiles.—These tiles, such as are used in the walls of bath rooms, kitchens, etc., are not vitrified, except as to the glaze. They are made in those shapes and sizes for which the manufacturer has moulds. Because of vagueness in trade catalogues, it is not always understood that these tiles are confined to the shapes and sizes mentioned in these catalogues.

Bright Colored Enameled Tiles.—The process of finishing these tiles consists in dipping any of the heretofore described bisques in bright glaze, stained to give the desired color. The range of colors and shades is restricted only by the manufacturer's ability to obtain stains. These tiles can also be supplied in all sizes and shapes.

Matt Glaze, or Dull Tiles.—These are made with bright colored glazes, in which is a mixture of acids that cause the colors to become dull, after they have been burned or fired. These colors are put on any of the bisques and are made in a wide range of colors, shades, and sizes.

Tiles that are glazed, on what is termed semi-vitreous and vitreous bodies, may be used for exterior decorations of buildings, because they are frost proof. They may also be used for decorative floors, as the combination of floor body and glaze is almost indestructible, is easily kept clean, and the range of artistic treatment is limited only by the conception of the designer.

Faience.—This type of tile which is quite recently being

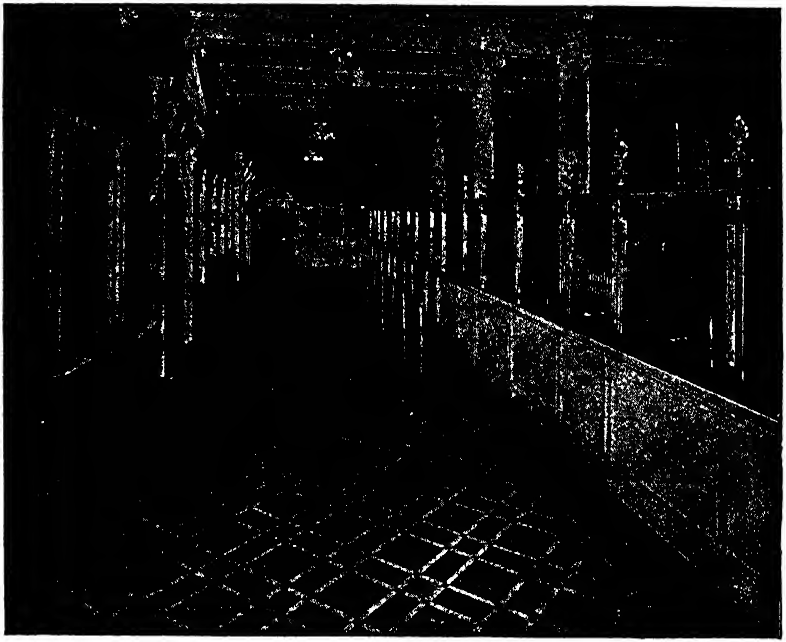


FIG 4,785 —Tiled floors and walls for banks Not only must the floor of service rooms withstand extremely heavy traffic as a whole, but particularly along certain fixed lines between teller's windows, toward elevators and other busy points A more suitable and appropriate material than tiles could not be chosen where traffic is extremely heavy or concentrated at certain points, and in use is, in fact, an effectual safeguard against shabbiness and unsightliness that result from uneven wear of floors, since wear and depreciation of tile floors are *nil*. The preservation of a true walking surface and other utilitarian qualities of a floor as much as its original color and attractiveness, are assured by the use of tiles.

developed in this country, is made on somewhat different principles. The word *faience* is French; and is taken from the name of Fienza, a town in Italy, the original place of manufacture of glazed decorative earthenware, especially that decorated in colors. In the 16th century Fienza had the reputation of making the finest glazed ware in the world.

Most of the faience bodies are termed *hand made*, giving them a crude rough texture. The bodies or bisques heretofore described are made of dried clay or dust, while faience bodies are made of wet or plastic clays.

Some claim that individuality and human feeling enter into the making of faience to an extent not obtainable in the dry pressed bodies. In any event, faience tiles are more irregular as to exact sizes, and the body lends itself to a richness in color and texture not obtainable by any other method of manufacture. Beautiful modeling may be secured at less cost of manufacture than by the dust process.

Faience tiles may be used for both exterior and interior embellishment for floors and walls the range of sizes, shapes, and colors having practically no limit.

Quarries.—The name *quarry*, as applied to tiles, has caused more controversy among those interested in the tile industry in this country, than any other product connected with tile making. Webster defines it in provincial english as *a square piece of turf or peat, a square brick or tile*. This much we do know—that they were made originally in Wales, of a natural rough clay found only there. The clay was mixed with water, rolled out in the same manner as dough, cut into square shapes with a piece of wire, and burned in open kilns, the same as a brick. Some were re-pressed after cutting, which improved the face and edges. For a long time Wales was the only known

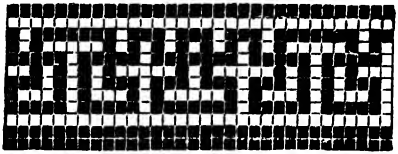
place in the world where quarries were made. Their chief appeal was extreme cheapness and durability.

During and since the great war, a number of American roofing tile makers have experimented with a natural shale, of which there is a vast quantity here, and have succeeded in making a very fair substitute, which they call quarries They have not, however, been able to produce the cherry red of the Welsh

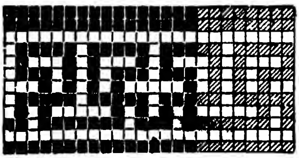
In England these quarries are used for garden walks, terraces, etc In this country they have been used whenever a strong rough floor is desired To some they have considerable appeal on account of their rough ruggedness. The sizes are 4 × 4, 6 × 3, 6 × 6, 9 × 9, and 12 × 12, and from ¾ to 2 thick

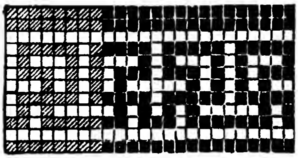
FIG 4 786 —Tiles floors and walls for dairies For this purpose the tiles are glazed or vitrified to a degree that makes them impervious and dirt and grease remain on the surface, where they can be easily and simply removed Tiling is durable fireproof easy to clean, inorganic, non absorbent requires no outlay for maintenance and can be installed without serious interruption to business Cleaning is an easy matter in a tiled dairy Spilled milk with its high percentage of fat is hard to remove from ordinary finishes but where non absorbent tiling is installed it is held at the surface, and is easily and quickly washed off No surface treatment or special process of cleaning is necessary to preserve tiles in a cleanly and sanitary condition

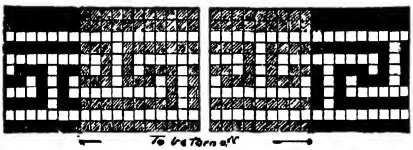
Ceramic Mosaic Tiles.—By definition tne term *ceramic*, means *the art of making things in baked clay*, such as pottery, tiles, etc., and *mosaics*, is *a surface decoration made by inlaying small pieces of glass, stone, or other material*—hence the name ceramic mosaic tiles.

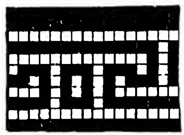


Ceramic mosaic tiles are made in several small sizes and shapes, notably $\frac{3}{4}'' \times \frac{3}{4}''$ square, $\frac{13}{16}''$ round, 1″ hexagon, $\frac{1}{2}'' \times 1''$, etc. They are also made in narrow strips, which may be cut into small pieces that permit of a wide range of pattern composition, both geometric and of the most intricate design.









FIGS. 4,787 to 4,792.—Borders of ceramic mosaic tile. ***These tile*** come in square, hexagonal and round shapes pasted on paper in plain colors or simple designs is such a convenient material to carry in stock with which to do small floors on short notice that he is frequently in the position of having to extempo ze the design on the floor with material that he has on hand. It is therefore necessary for him to keep in mind certain simple considerations which in the case of larger oors are met by the factory designer. Never lay an ornamental border directly against the wall Always use two inches or more of plain or uniform color as margin preferably of a darker tint than the general tone of the border and body.

They are made semi-vitreous, vitreous, and glazed, both bright and dull.

Ceramic mosaic tiles are uniformly about $\frac{1}{4}''$ thick and are mounted on paper in sheets $2' \times 1'$, thus affording great economy in handling by the tile setters. They are used for both wall and floor covering and permit of as wide a decorative scope as the imagination of the artist can conceive.

In addition to the description of the several tiles mentioned, there are a number of others many of which are used by individual tile makers, to describe their own particular product. Some of them have no special

relation to tiles, but all have more or less significance and are used to describe glazes or textures.

Schedule of Tiles.—The following schedule adopted by The Associated Tile Manufacturers giving names, descriptions, colors and sizes should be carefully noted.

Schedule of Tile

(According to The Associated Tile Manufacturers)

1. Mosaic.

Unglazed ceramic mosaic.

Enamel mosaic
Glazed mosaic
Dull glazed mosaic.
Matt glazed mosaic.

b. Cut mosaic.
c. Plastic mosaic.
d. Faience.

2. Vitreous and semi-vitreous.

a. Unglazed vitreous and semi-vitreous tiles.

Glazed
Dull glazed.
Matt glazed.

3. Paving tiles.

a. Flint tiles.
b. Hydraulic tiles.

Corrugated paving tiles.
Rough red paving tiles.

4. Inlaid and quarry tiles.

a. Inlaid tiles.
b. Quarry tiles.

5. Glazed tiles and enamels.

a. White glazed tiles.
b. Enamels.
c. Dull glazed tiles.
d. Matt glazed tiles.

6. Plastic tiles and Faience.

a. Plastic tiles.
b. Faience.

Mosaic

Ceramic Mosaic. This is the collective term for unglazed dust pressed tesseræ ¼ inch thick and less than 2¼ square inches in area. These are vitreous or semi-vitreous as listed.

Enamel Mosaic are ceramic mosaic tesseræ of any of the regular sizes, shapes, and body colors as listed when glazed with a bright finish *colored* glaze. The glaze may be transparent, translucent, or opaque, and the body color accordingly may or may not be visible through the colored glaze.

Glazed Mosaic are ceramic mosaic tesseræ of all sizes, shapes, and body colors as listed when glazed with a *bright finish, clear, colorless* glaze. Because of the transparency of the glaze, the body color of the tesseræ is retained and the range of colors is limited to those in which unglazed ceramic mosaic is made.

Dull Glazed Mosaic are ceramic mosaic tesseræ of any of the regular sizes, shapes, and body colors when glazed with a *dull finish white or colored* glaze.

Matt Glazed Mosaic are ceramic mosaic tesseræ of any of the regular sizes, shapes, and body colors when glazed with a *matt finish white or colored* glaze.

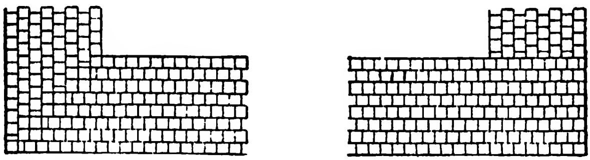
Plastic Mosaic. This term is used as a designation for tesseræ of any

shape or size less than 2¼ square inches in area made by the plastic process, in colors that result from the firing of natural clays.

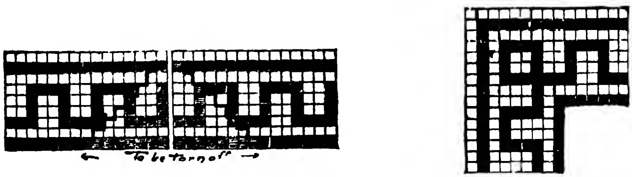
Faience Mosaic. This term is used as a designation for all plastic mosaic tesseræ when glazed. The glazes may be bright, dull, or matt finish. Colors should be selected from samples and specified by the numbers which the member factories use for identification purposes.

Mounting. All Mosaic is regularly furnished mounted on paper in sheets about 2 ft. × 1 ft., but can also be obtained loose.

Cut Mosaic. This is the trade term for unglazed, dust pressed, vitreous or semi-vitreous strips, ¼ inch thick, and either 6×⅝, 3×⅝, or



FIGS. 4,793 and 4,794 —Corners in ceramic mosaic tile. If the plain material in broken joints treat the corners by tearing a mitre in the sheets so that each row of tile will seem to run around the corner (see illustration).



FIGS. 4,795 and 4,796 —Corners in ceramic mosaic tile. It is unnecessary to carry a stock of corners with simple ceramic borders as these can almost always be extemporized easily by tearing the running border sheets into mitres and fitting them together so as to make a corner figure

3×½ inches in size, which are made for cutting into irregular tesseræ necessary in the production of ungeometrical designs and pictorial work. The colors include all Unglazed Ceramic Mosaic colors and granites. Furnished in loose strips or in assembled designs mounted on paper.

Trimmers. These include combination quarter-rounds and coves, and outside and inside angles, for use with flat mosaic tiles.

Ceramic Mosaic

Vitreous

Grades

Selected only (except white, of which a small quantity of the commercial grade is available)

Colors

White, celadon, silver gray, green, blue green, light blue, dark blue, pink, cream, and "granites" of these colors

Sizes

Square ¾" ½"
Oblong
2$\frac{1}{16}$" × 1" 1$\frac{1}{16}$" × ½"
Hexagon 1¼" 1"
Round $\frac{13}{16}$"
Thickness ¼"

Semi-Vitreous

Grades

Selected only

Colors

Buff, salmon, light gray, dark gray, red, chocolate, black, and "granites" of these colors

Sizes

Square ¾" ½"
Oblong
2$\frac{1}{16}$" × 1" 1$\frac{1}{16}$" × ½"
Hexagon 1¼" 1"
Round $\frac{13}{16}$"
Thickness ¼"

Vitreous and Semi-Vitreous Tiles

Vitreous and Semi-Vitreous Tiles. These are group designations for unglazed dust pressed tiles ½ inch thick. They are vitreous or semi-vitreous according to color.

Glazed Vitreous and Semi-Vitreous Tiles are the vitreous and semi-vitreous tiles as listed when glazed with a bright, clear, and colorless glaze. The principal characteristic of these tiles is that, because of the transparency of the glaze, the body color is retained. The range of colors is limited to those in which unglazed vitreous and semi-vitreous tiles are made.

Dull Glazed Vitreous and Semi-Vitreous Tiles are tiles of any of the regular sizes. shapes, and body colors as listed when glazed with a ***dull finish*** white or colored glaze.

Matt Glazed Vitreous and Semi-Vitreous Tiles are tiles of any of the regular sizes, shapes, and body colors as listed when glazed with a ***matt finish*** white or colored glaze.

Vitreous and Semi-Vitreous Trimmers are unglazed, dust pressed, standardized shapes to serve as coves, quarter-rounds, angles, bases, etc They are also furnished, when necessary, with glazes corresponding to those of the flat tiles.

Vitreous

Grades

Selected and Commercial

Colors

White, celadon, silver gray, green, blue green, light blue, dark blue, pink, cream, and granites of these colors

Sizes

Square 3″ $2\frac{1}{8}$″ $1\frac{1}{2}$″ $1\frac{1}{16}$″

Oblong
3″ × $1\frac{1}{2}$″ 3″ × 1″
3″ × $\frac{1}{2}$″ $2\frac{1}{8}$″ × $1\frac{1}{16}$″
$1\frac{1}{16}$″ × $\frac{17}{32}$″

Octagon 3″
Hexagon 3″ 2″

Triangle 3″ $1\frac{47}{64}$″ $1\frac{5}{32}$″
Thickness $\frac{1}{2}$″

Semi-Vitreous

Grades

Selected only

Colors

Buff, salmon, light gray, dark gray, red, chocolate, black, and granites of these colors

Sizes

Square 6″ $4\frac{1}{4}$″ 3″ $2\frac{1}{8}$″ $1\frac{1}{2}$″ $1\frac{1}{16}$″

Oblong
9″ × 3″ $4\frac{1}{4}$″ × $2\frac{1}{8}$″
6″ × 4″ $4\frac{1}{4}$″ × $1\frac{1}{16}$″
6″ × 3″ 3″ × $1\frac{1}{2}$″
6″ × 2″ 3″ × 1″
6″ × $1\frac{1}{2}$″ 3″ × $\frac{1}{2}$″
6″ × $\frac{3}{4}$ $2\frac{1}{8}$″ × $1\frac{1}{16}$″
6″ × $\frac{1}{2}$″ $1\frac{1}{16}$″ × $\frac{17}{32}$″

Octagon 6″ $4\frac{1}{4}$″ 3″
Hexagon 6″ 6″ × 3″ $4\frac{1}{4}$″ $4\frac{1}{4}$″ × $2\frac{1}{8}$″ 3″ 2″
Pentagon $5\frac{5}{16}$″ × $2\frac{1}{8}$″
Triangle 3″ $1\frac{47}{64}$″ $1\frac{5}{32}$″
Thickness $\frac{1}{2}$″

Paving Tiles

Paving Tiles. This term is a group designation for unglazed dust pressed tiles ¾ inch thick. These are vitreous or semi-vitreous according to the schedule.

Flint Tiles are unglazed vitreous paving tiles as listed.

Hydraulic Tiles are unglazed semi-vitreous paving tiles as listed

Trimmers. These are certain vitreous and semi-vitreous shapes to serve as coves, angles, bases, etc., in connection with the flat paving tiles, and are the same as made for vitreous and semi-vitreous tiles.

Flint—Vitreous

Grades

Selected and Commercial

Colors

White, light gray, dark gray, pearl gray, celadon, sage, light blue, dark blue, green, cream

Sizes

Square 6″ 4¼″
Oblong
6″ × 4″ 6″ × ½″
6″ × 3″
Octagon 6″
Hexagon 6″ 4¼″

Thickness ¾″

Semi-Vitreous—**Hydraulic**

Grades

Selected only

Colors

Red, light gray, dark gray, buff, black, salmon, chocolate, and granites of these colors

Sizes

Square 6″ 4¼″
Oblong
9″ × 3″
6″ × 3″
10″ × 5″
6″ × ½″
Hexagon 6″ 4¼″
Thickness ¾″ and 21/32″

Corrugated Paving Tiles are semi-vitreous, unglazed, dust pressed paving tiles 13/16 inch thick and 6 inches square with a corrugated face.

Rough Red Paving Tiles are semi-vitreous, unglazed, dust pressed tiles ½ inch thick (except 9 × 9 inches, which are ⅝ inch thick) in sizes 9 × 9, 9 × 4½. 6 × 6. and 6 × 3 inches.

Inlaid and Quarry Tiles

Inlaid or Encaustic Tiles are unglazed dust pressed decorative tiles ½ inch thick, produced by inlaying a figure or ornament of one or more colors into a body of a contrasting or harmonizing color before firing. They are vitreous or semi-vitreous according to the colors

Quarry Tiles is a term for machine-made unglazed tiles, ¾ inch or more in thickness, made from common clays

Inlaid Tiles

Grades

Selected only

Colors

Buff and red, buff and chocolate, black and buff, red, black, and buff, blue and white, white and sage white, blue, and red

Sizes

Square 6″ 4¼″ 3″ 2⅛″ 1½″
Oblong
6″ × 3″ 4¼″ × 2⅛″
6″ × 1½″
Thickness ½″

Quarry Tiles

Grades

Selected only

Colors

Red, red granite, light gray granite, dark gray granite, black granite, chocolate granite, light brown granite dark brown granite, green granite

Sizes

Square 9″ 6″

Thickness 1″ and ¾″

Trimmers for Inlaid and Quarry Tiles are the same as those made for Vitreous and Semi-Vitreous Tiles

Glazed Tiles and Enamels

White Glazed Tiles. These are dust pressed glazed tiles ½ or ⅝ inch thick according to size with white body, and a bright finish transparent glaze

Enamels are dust pressed tiles ½ inch thick with a *bright finish colored* glaze, transparent or opaque, on a white or colored body

Dull Glazed Tiles are dust pressed tiles ½ inch thick with a *dull* finish and translucent or opaque glaze in white or colors on a white or colored body.

Matt Glazed Tiles are dust pressed tiles ½ inch thick with an opaque glaze devoid of all gloss in white or color on a white or colored body

Colors The vagueness of color nomenclature prevents the preparation of a list of the almost endless number of colors and shades in which glazed tiles are produced Selection should be made from samples and the color specified by number Each member factory has its own range of colors and method of numbering

Trimmers are tiles in standardized shapes such as coves, quarter-rounds, bases, caps, angles, architraves, mouldings etc They are furnished in bright dull or matt finish glazes and in enamels

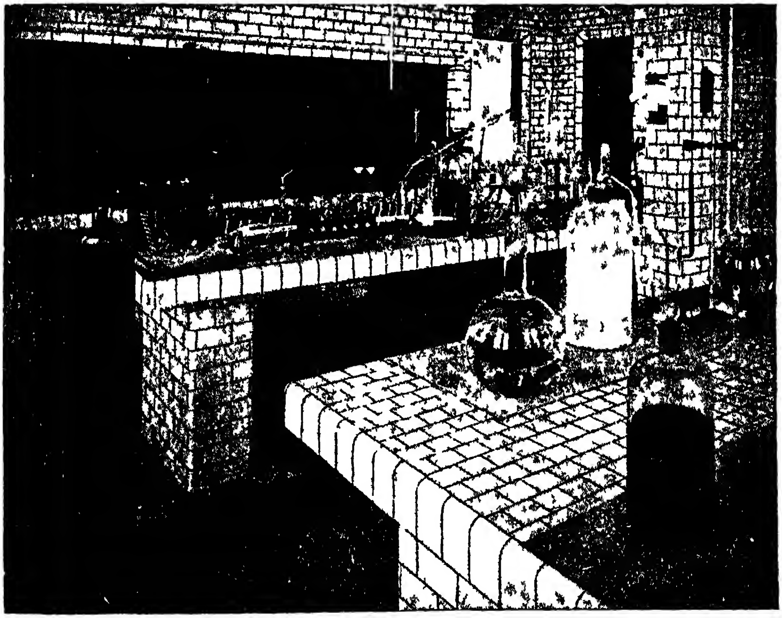


FIG 4 797 —Tiles for chemical laboratories ***For this purpose*** the tiles are set in acid resisting cement, producing a surface proof against the reaction of alkalis and acids excepting hy irofluoric

White Glazed

Grades

For regular sizes in bright finish: Selected, Standard, and Commercial; For other sizes: Selected and Commercial

Colors

White

Surfaces and Finishes

Bright only
Plain or embossed

Regular Sizes

Square 6″ 4¼″
Oblong
6″ × 3″ 4¼″ × 2⅛″
6″ × 2″

Other Sizes

Square 3″ 2⅛″ 1½″ 11/16″ ¾″ ½″
Oblong
6″ × 1½″ 3″ × 1½″
6″ × 1″ 3″ × 1″
6″ × ¾″ 3″ × ½″
6″ × ½″ 3″ × ¼″
4¼″ × 11/16″ 2⅛″ × 11/16″
Octagon 3″
Hexagon 3″ 2″
Thickness
½″ except 4¼″ × 4¼″, 6″ × 3″, 6″ × 2″ and 4¼″ × 2⅛″ which are ¾ thick

Dull and Matt Glazed and Enamels

Grades

Selected and commercial

Colors

See opposite page

Surfaces and Finishes

Glazed: Dull and Matt
Enamels: Bright only
Plain or embossed

Sizes

Square 6″ 4¼″ 3″ 2⅛″ 1½″ 11/16″ ¾″ ½″

Oblong
6″ × 3″ 4¼″ × 2⅛″
6″ × 2″ 4¼″ × 11/16″
6″ × 1½″ 3″ × 1½″
6″ × 1″ 3″ × 1″
6″ × ¾″ 3″ × ¼″
6″ × ½″ 2⅛″ × 11/16″
Octagon 3″
Hexagon 3″ 2″

Thickness ½″

Plastic Tiles and Faience

Plastic Tiles are unglazed plastic-made tiles in natural colors regardless of size, shape, or thickness.

Faience is the name given to glazed plastic-made tiles regardless of size, shape, thickness, or color, in bright, dull or matt finish.

Colors. Because of the vagueness of color nomenclature and the almost unlimited possibilities and varied combinations of colors, it is impracticable to present even a partial list of the colors and finishes produced. Selection should be made from samples and the colors specified by the numbers which the factories use for identification purposes.

Trimmers. Bases, caps, mouldings, etc., in plastic tiles and faience, are made in regular shapes and also special, according to effects desired.

Plastic

Grades

Selected only

Colors

Natural clay colors

Surfaces and Finishes

Smooth or rough
Plain or embossed

Sizes

Obtainable in regular and special sizes. The production of special sizes is not subject to the same restrictions as in the dust process, and special sizes can readily be made

Thickness ½″ and over, according to size and conditions

Faience

Grades

Selected and Commercial

Colors

See above

Surfaces and Finishes

Bright, dull, matt
Plain or embossed

Sizes

Obtainable in regular and special sizes. The production of special sizes is not subject to the same restrictions as in the dust process, and special sizes can readily be made

Thickness ½″ and over, according to size and conditions

Manufacture of Tiles.—The art of tile making and working in clay is the oldest known effort of man to create something useful for his requirements. There are specimens in museums known to have been made 6000 B. C. In considering tiles we are dealing with a product which has interested and delighted antiquarians.

Previous to the Centennial Exposition, held in Philadelphia in 1876, tiles were not well known in this country although they were in common use in Europe. Some English manufacturers showed comprehensive exhibits

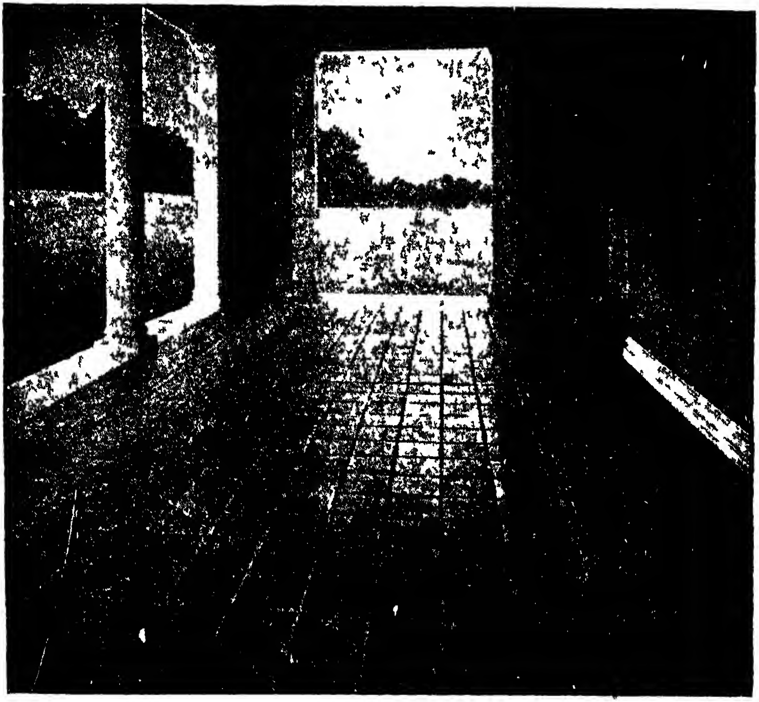


FIG. 4,798.—Porch tiling. Because they are inorganic tiles do not deteriorate when exposed to the weather, hence they are especially suitable for exposed places. Moreover, tiles do not stain easily and will not fade nor corrode.

at this exposition, which stimulated progressive American manufacturers. One factory was started in Ohio and another in Indiana.

Tiles are made from natural clays, or from different kinds of clays, feldspars, and flints which are obtained from domestic banks and quarries or imported from other countries, and are selected, proportioned, and mixed according to the kind of tiles to be manufactured. These raw materials undergo a variety of refining and mixing processes before they become suitable for forming or pressing into tiles.

There are two different ways of making tile, known as:

1. The plastic process.
2. Dust pressed process.

The Plastic Process.—In this process the materials are mixed with water and run through pugging machines until of a uniform plastic consistency. In this condition they are pressed, either by hand or machine in dies or moulds, and after drying, are put into burned clay containers known as saggers, in which they are sent through the kilns and fired.

The plastic nature of the material has a tendency to produce tiles that vary slightly from the true geometric shapes and bring about the pleasing irregularity characteristic of plastic made tiles.

The Dust Pressed Process.—In this process, the materials, after being finely ground and mixed with water, are passed into filter presses where the excess water is pressed out. The resulting mass is dried and pulverized and then pressed into shape in metal dies. Every piece is inspected, fettled, if necessary, to remove feather edges, and is then placed in the saggers and sent through the kilns. The tiles in this unburned state are called green tiles.

Firing in Kiln.—All tile whether made by the plastic process

or dust pressed process are subjected to high temperature by firing in the kiln. Here they are given either:

1. A single firing, or
2. A double firing,

according as the finished tile is unglazed or glazed.

Unglazed Tiles; Single Firing.—The one firing brings them to their respective degrees of vitrification, colors, and surface texture. It lies in the nature of the raw materials and color ingredients that some can be fired to complete vitrification, while others do not permit this because physical destruction of the product would result. Hence, the unglazed tiles are burned either vitreous or semi-vitreous, according to their colors as listed in the schedule already given. According to Kidder the vitreous tiles are "the hardest tiles known: and cannot be scratched by steel or sand, are non-absorbent and thoroughly aseptic."

Glazed Tiles; Double Firing.—The "green" tiles which are to be given a glazed surface, are first fired in the biscuit kiln at a temperature of over 200° Fahr. The firing produces the "*biscuit*," "bisque" or "body," made either plastic or by the dust pressed method.

The biscuit is subsequently coated with the glazing liquid, made from pulverized flint, feldspar, clay and a flux, and is placed in the gloss kiln, where it is subjected to slightly lower temperatures (second firing) which produce the glaze and unite it with the biscuit.

The resulting silicious coating is known as *glaze* and manufacturers distinguish between glazes, enamels and dull finishes according to the ingredients and characteristics of the coating.

Trade custom, however, has extended the application of the word "enamels" for instance, to designate a kind of tile, namely, those having a white body and a *bright finish colored* glaze.

Again the same kind of tile with a colorless glaze is commonly *called*

white glazed tile. Conversely, the white tiles generally used for wainscoats in bath rooms are called *glazed* and the same tiles with a colored glaze in a bright finish are called *enamels*. Both glazes and enamels are entirely vitreous coatings.

How Colors are Produced.—The colors of dull and matt glazed tiles and Faience are produced by various metallic oxides which stain the base or flux of the glaze while it is in a state of fusion. Certain color effects, particularly in Faience,

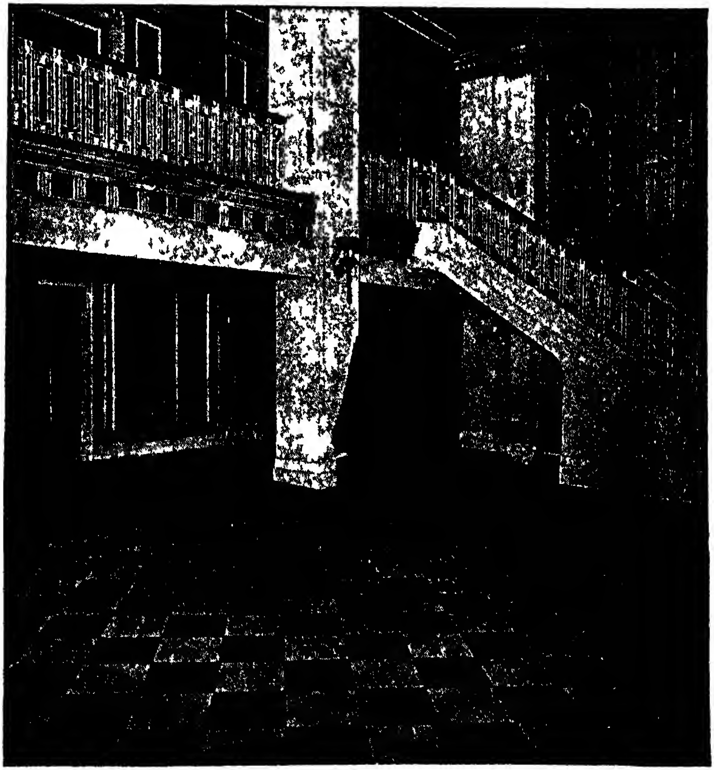


FIG 4,799.—Theatre tiling.

require more than one firing. In such cases the temperature of the kiln has to be changed or adjusted to different fusion points at which the ingredients of the successive glazings develop the various colors.

An important practical property of all colored glazes and enamels is that of being entirely non-fading. The range of colors and tints is almost unlimited and virtually any color effect or combination can be obtained.

Surface Finish.—The glazes and enamels are so proportioned and so fired that, as predetermined by the effect desired or texture to be obtained, the surface will result in a bright, dull, or matt finish. The bright have a surface or high gloss, the matt are entirely devoid of gloss, and the dull finishes lie intermediate between these extremes.

Finishes such as eggshell, vellum, orange skin, crocodile skin, crystalline, etc., are varieties of the dull and matt, and present an extensive line of surface textures.

Crazing.—This is a term given to minute crackling which sometimes becomes visible on the surface of glazed ware. Tiles cannot be guaranteed against crazing.*

Sorting and Grading.—Tiles are not, and cannot be, manufactured in predetermined grades or qualities. The object of the makers is to produce but one grade, viz., the highest obtainable with the materials and forces at their disposal.

*NOTE—*In former years* manufacturers were willing to guarantee glazed tiles against crazing This, however, is not now done or required, since producers and specification writers alike realize that crazing of a glazed surface cannot be absolutely controlled One of the causes of the phenomenon known as crazing is the slightest kind of a difference in the coefficients of expansion and contraction between the materials of the body and those of the glaze Other more frequent causes of crazing have been traced to unequal settlement and to the expansion and contraction of foundations, as well as to physical and chemical changes which may take place in backgrounds and foundations upon which tiles are set.

Because of limitations in the processes and the difficulty of absolute control in firing conditions, certain variations in shades, sizes, etc., take place which are inherent in the manufacture of clay products.

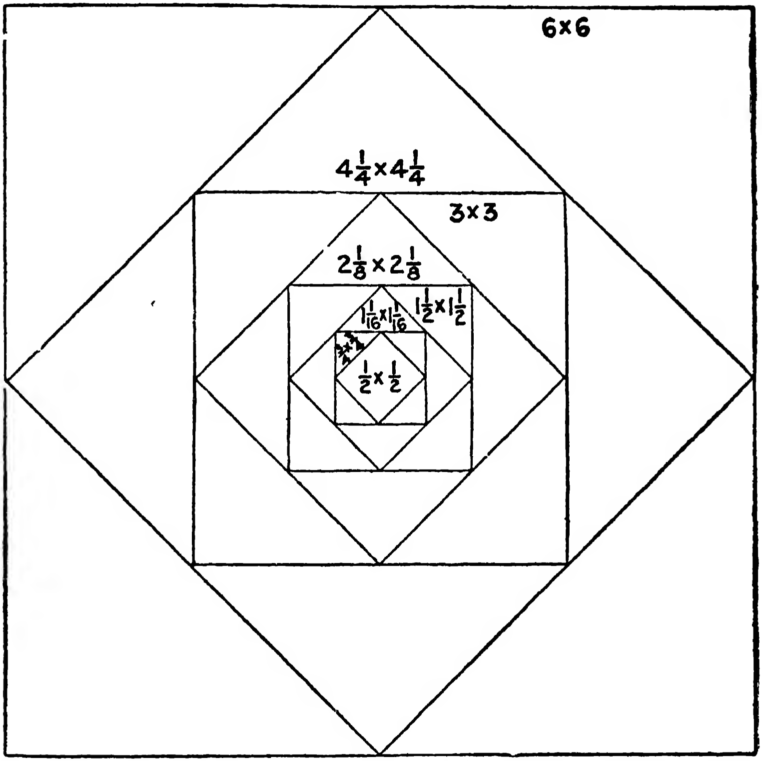


FIG. 4,800.—Basic 6 in. square with inscribed squares and diagonal halves from which the following tile shapes are obtained *Squares:* 6 × 6, 4¼ × 4¼, 3 × 3, 2⅛ × 2⅛; 1½ × 1½; 1¹⁄₁₆ × 1¹⁄₁₆ × ¾ × ¾; ½ × ½, *diagonal halves:* 6 × 6, 4¼ × 4¼, 3 × 3, 2⅛ × 2⅛; 1½ × 1½; 1¹⁄₁₆ × 1¹⁄₁₆, ¾ × ¾.

Tile makers therefore sort the tiles, after they come from the kilns, into different grades

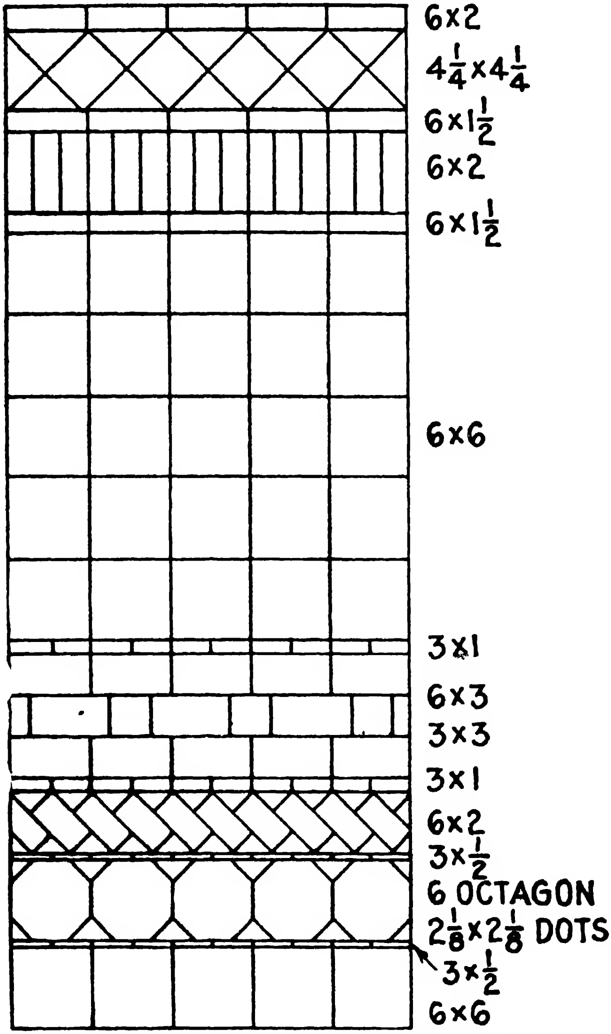
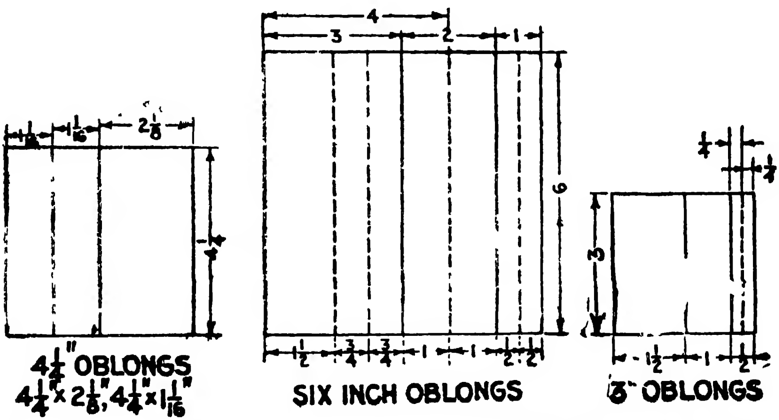


FIG 4,801 —Various combinations of the basic 6 in square with inscribed squares and diagonal halves

With respect to wearing and sanitary qualities no difference exists in these grades, as surface blemishes, warpage, and appearance alone are the basis for the grading.

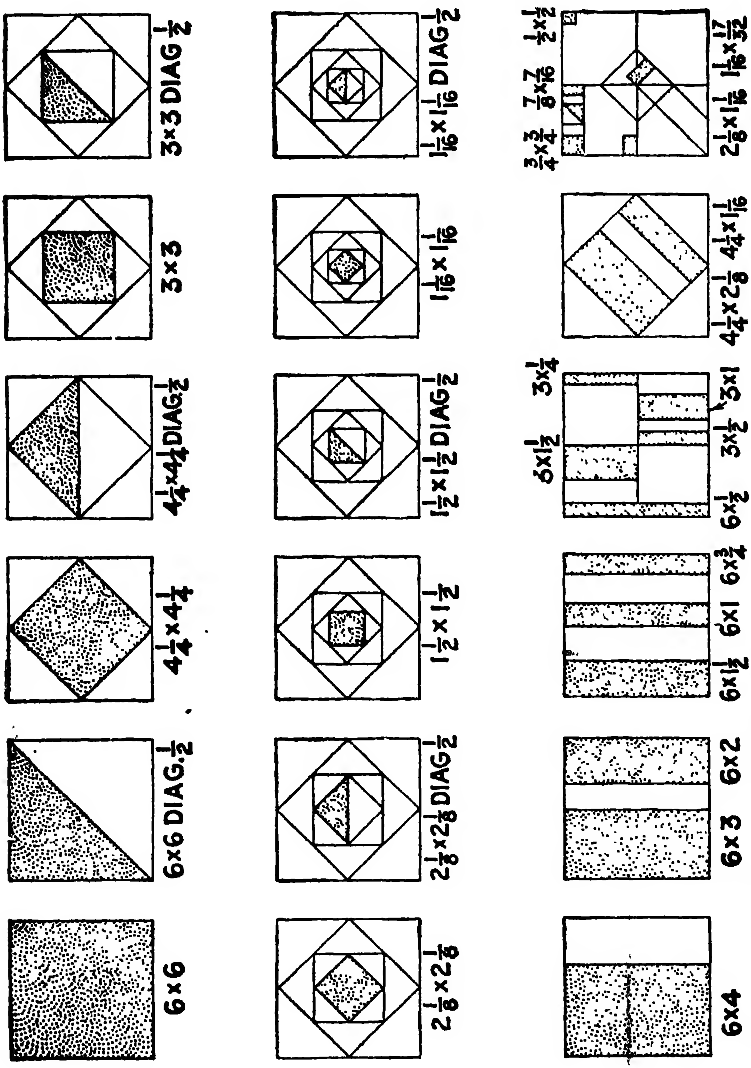
The sizes and thicknesses tabulated in the schedule and shown by the drawings for various kinds of tiles should always be considered as subject to slight variations, or "tolerances," as



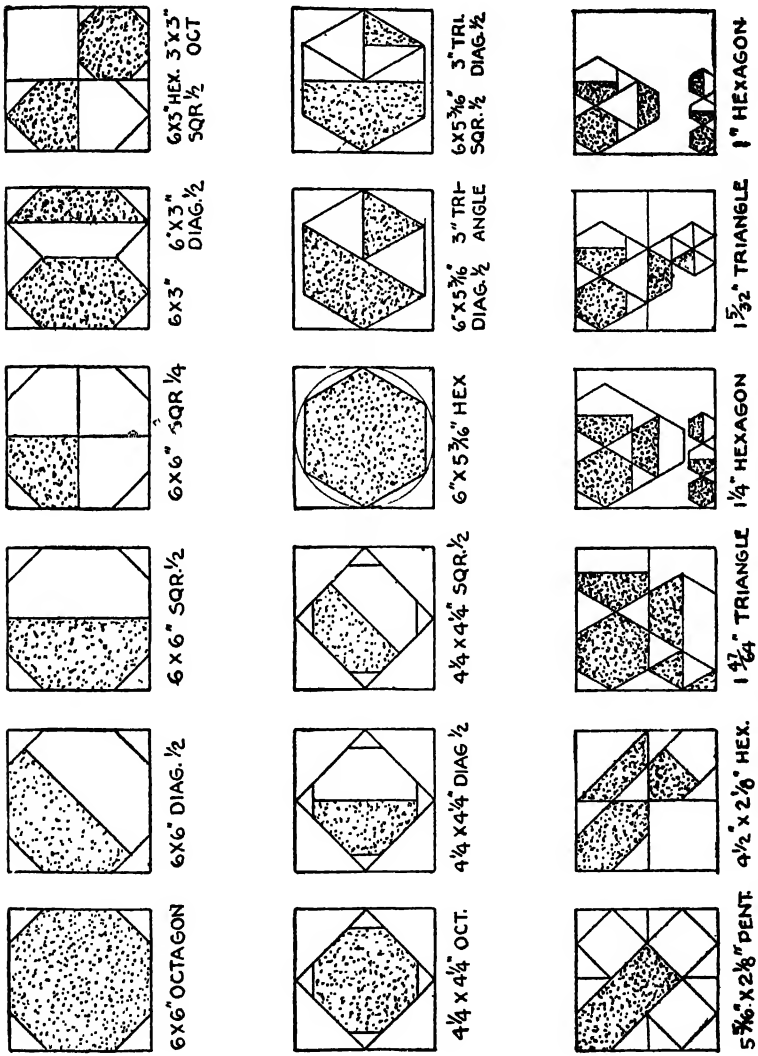
FIGS. 4,802 to 4,804 —Various oblongs resulting from the three larger squares of fig. 4,800. *Six in. oblongs:* 6 × 4; 6 × 3; 6 × 2, 6 × 1½; 6 × 1; 6 × ¾; 6 × ½; *four and one-quarter in. oblongs:* 4¼ × 2⅛; 4¼ × 1 1/16, *three in. oblongs:* 3 × 1½; 3 × 1; 3 × ½; 3 × ¼.

in the case of all clay products, since the materials and forces of nature employed in their production are not susceptible to complete control.

Grades should be considered from the appearance of the tiles in the mass, since no single tile can be truly representative of any particular grade.



FIGS. 4,805 to 4,822.—Development of tile shapes.



FIGS. 4,823 to 4,840.—Development of tile shapes.—*Continued.*

Tiles are generally graded as:

1. Selected.
2. Commercial.

The selected grade represents picked tiles of practically uniform quality, while in the commercial or cheaper grade, the quality varies within limits such that it will be satisfactory for ordinary work.

Tile Sizes.—The basis for all regular sizes of modern tile is a six inch square, this being handed down from medieval potters and still in use at the present time.

Fig. 4,800 shows the method of division into shapes which result in squares of the sizes given with their related diagonal halves and quarters. All these squares, by adding suitable diagonal halves, work out to the original unit as shown in fig. 4,801.

The three larger squares resulting from this geometrical pattern are again divided into the oblong shapes and sizes as shown in figs. 4,802 to 4,804.

Various shapes in common use are those derived from the octagon, hexagon and other geometrical figures which, together with the resultants to the sub-divisions as shown in figs. 4,805 to 4,840.

Tile, Terms and Definitions

Tile.—A designation for all types of glazed and unglazed tiles, made exclusively from clay, with or without other ceramic materials, and burned in in the course of manufacture. They are made in sizes which can be handled conveniently, installed individually or in multiple units, and used exclusively as facing or surfacing for interior or exterior walls, floors, pavements, ceilings, etc., and are not a structural unit.

Cement.—Cement for use in mortars, setting beds, grouting, and all other operations in connection with the tile work refers to a standard grade Portland cement of domestic manufacture. All Portland cement shall be of a color other than white unless otherwise designated.

Lime.—Lime for use in mortars, setting beds, and all other operations in the tile work refers to a high calcium type lime putty, as prepared from domestic hydrated lime or properly slaked quicklime.

Mortar.—A mixture of cement, with or without lime putty, fine aggregate and water, with or without the addition of admixtures, such as integral waterproofing compounds.

Aggregates.—The term "aggregates" applies to the non-cementatious materials, such as sand in tile mortars and sand, gravel, and stone used in concrete fill and other operations in connection with the tile work.

Concrete Fill.—The layer or bed of concrete serving as the underfill and base for floor tile and other horizontal tile installations. It is applied upon the sub-floor to a thickness sufficient to bring the mortar setting bed and tile to the proper surface level.

Cleavage Plane or Cushion.—A layer of material, such as sand or building paper, used to separate the concrete fill or mortar setting bed from the sub-floor or other structural base, to permit a possible independent movement of the sub-floor or structural base.

Mortar-Setting Bed.—The layer or bed of mortar applied to the concrete fill or other sub-floors and sub-walls upon which the tiles are laid and beaten in.

Scratch Coat.—A mortar bed applied directly upon the metal lath, hollow tile or other types of sub-walls for the purpose of providing a sufficiently strong and rigid surface upon which the mortar setting bed or the plumb coat can be properly applied, and also to act as an absorption regulator when applied to bases of a porous nature. The scratch coat is scored, scratched or grooved to insure a key and bond with the mortar setting bed.

Buttering.—A method of applying the mortar setting bed upon the tile before placing the tile and mortar upon the scratch coat. In this method, a sufficient quantity of mortar is spread upon the back of each tile unit, so that when the tile and mortar are placed upon the scratch coat, the tile can be tapped to the required surface level.

Floating.—A method of applying the mortar setting bed upon the scratch coat and placing the tile thereon. In this method, the mortar is troweled or spread upon the scratch coat to a true plumb surface and is of sufficient thickness to bring the subsequently applied tile to the required surface line. A thin skim coat of neat cement is spread upon this mortar bed or on back of each tile unit, and the tiles are beaten into the mortar bed to the required finished surface line.

Screeds or Screed Strips.—A wooden strip section or a part of mortar laid on a floor or wall at intervals to gauge the thickness of setting beds or to indicate the finished tiled surface.

Grouting and Pointing.—The method of finishing the joints of all tile work by filling them with cement or a mortar.

Inserts.—Isolated or grouped tiles, plain or decorated, set in a finished surface of tile or other materials, such as brick, stone, stucco, concrete or cement, whether on interior or exterior walls or floors.

Trimmers or Trim.—Bases, caps, corners, angles, architraves, and other tile mouldings and shapes to suit various kinds, shapes and sizes.

Types of Tile.

There are two general kinds of tile—glazed and unglazed. Each of these is composed in various types:

Shapes and Sizes.—The shapes and sizes of tile available allow wide architectural freedom and design, but for economy and convenience the industry has adopted certain approximate standards which can be furnished by most manufacturers. Individual manufacturers make additional sizes and shapes which are special.

Degrees of Vitrification of Tile.

Impervious.—That degree of density of either the tile glaze or the body which will not permit the absorption of any liquid or grime, and from whose surface any stains or grime may be easily removed.

Vitreous.—That degree of density of tile body which will absorb less than 3 per cent of moisture, and which will not permit any grime penetration into the face of the tile which cannot be readily removed.

Semi-Vitreous.—That degree of density of tile body which will absorb more than 3 per cent, but less than 7 per cent of moisture.

Non-Vitreous.—That degree of density of body which (although having high strength) will absorb more than 7 per cent of moisture.

Each of the different degrees of vitrification has advantages for certain purposes. For instance, glazed interior tile, which is the glazed tile most commonly used for interior wall installations, has a non-vitreous body with an impervious glazed face. It is durable and lends itself more readily to faster installation than a more vitreous tile, thereby reducing the cost of installation below that of glazed semi-vitreous or vitreous bodies. Likewise, semi-vitreous unglazed tile permits development of certain color effects which cannot be produced in a vitreous or impervious unglazed tile.

Glazed Tile.

General.—A glazed tile is a tile which has a glass-like surface composed of ceramic materials fuzed upon its surface. Such glazed surface is impervious. It does not absorb stains nor change color. Ink, pencil markings, oil, and grease may be easily removed. Ordinary acids will not injure glazes except as especially stated herein.

The body of the tile may be composed of white or colored clays or other ceramic materials. It may vary in degree of vitrification or absorption according to the purpose for which the tile is intended. The body of the tile, its color, its method of manufacture, and the glaze applied thereon may be produced by various methods suitable to the individual manufacturer except as otherwise stated herein.

Color and Finish of Glaze.—The glaze on tile may be clear, opaque, white, black, colored, or polychrome with smooth, mottled, veined or ripple effect. The finish of the glaze may be bright, semi-matte or matte. Each glaze has its own characteristic finish, which is an inherent part of the glaze, and cannot be changed readily to meet personal preference.

Bright, Semi-Matte and Matte Glazes.—The surfaces of glazed tile vary in light reflecting properties. If the glazed surface reflects an image, it is called a *bright glaze*. A glaze surface which does not reflect an image is called a *matte glaze*. Surface finishes between a bright and a matte glaze, are termed *semi-matte*.

A method of determining whether a glaze is bright (reflecting) or matte (non-reflecting) is as follows: Place a piece of tile in a vertical position upon a horizontal surface with its face parallel to the direction of the strongest source of light. Then place a white envelope on the horizontal surface two inches in front of the glazed face of the tile. If the outline of the edges of the envelope are visible on the face of the tile, it is termed a bright glaze. If the tile does not reflect the image of the edge of the envelope, it is termed a matte glaze.

Uses.—Proper use of glazes should be recognized. Bright surface glazes may be used on walls, *but should not be used on floors at any time.* Semi-matte glazes may be used satisfactorily on interior wall surfaces, and on floors subject to limited floor traffic. Matte finish glazes, on the proper body, can be used for interior walls and floors restricted to reasonable residential wear.

Weatherproof.—The word *weatherproof* as used, means that representative samples of tile to which the name applies will withstand the standard freezing tests used by the Tile Industry Research Bureau without disintegration of the tile.

Glazed Interior Tile.—Symbol GI. This designates a durable tile having an impervious glazed face with a white or colored body composed of clay or other ceramic materials. This type of tile is suitable for use in interior locations not subject to freezing temperatures in the presence of water. The thickness of this tile shall be at least ¼ inch, for units up to 36 square inches in facial area, and at least ½ inch for larger units.

Glazed Weatherproof Tile.—Symbol GW. This designates a tile having an impervious glazed face and a semi-vitreous or vitreous white or colored body composed of clay and other ceramic materials, and which will pass the standardized freezing tests as established by the Tile Industry Research Bureau.

The thickness of this type of tile is usually ½ inch, but it may be a minimum of ⅜ inch, if less than 36 square inches in facial area.

To be entitled to this name the tile must withstand the standard tests for "Weatherproof."

Faience Tile.—This designates a tile having an impervious glazed and a dense body which is formed while in its plastic state and made principally from clay and other ceramic materials.

The appearance of this tile is characterized by a rugged, individual, although artistic variation of the face and edges like that occurring in handicraft methods of forming and finishing in the plastic state.

This type of tile usually has a heavier coating of glaze than glazed interior tile, and is more subject to heavier deposits of the glaze at the edges of the tile. It is well adapted to and widely used for manufacturing special architectural shapes or designs having a glazed finish. It is also obtainable in a large variety of sizes, shapes and designs.

The tiles of this type are:

Faience Mosaics.—Symbol FM. Tile between ¼ inch and ⅜ inch in thickness which is less than six square inches in facial area.

Weatherproof Faience Mosaics.—Symbol WFM. Tile which withstands the "Weatherproof" test without disintegration and conforms to sizes stated for "Faience Mosaics."

Faience —Symbol FT. Tile at least ½ inch thick, varying to greater thickness for the larger sizes. This tile is larger than 6 square inches in facial area, except in cases where smaller sizes are needed to complete a pattern with the larger sizes.

Weatherproof Faience.—Symbol WF. Tile which withstands the "Weatherproof" test without disintegration and conforms to "Faience" as previously stated.

Unglazed Tile.

General.—Unglazed tile is composed of the same ingredients throughout the entire body (mass) as appear upon the face of the tile. The ingredients of the body may be clay, shale, or other ceramic materials, and manufactured by various methods. The surface may be either plain, mottled, or "fire-flashed."

Ceramic Mosaic.—This designates certain standard sizes of unglazed tile which are less than 6 square inches in facial area and approximately ¼ inch to ⅜ inch thick.

NOTE.—Ceramic mosaic is usually pasted on sheets of paper to assist in setting. It is usually arranged in a mosaic pattern formed by the size or color of the tile.

Paver.—This name designates certain sizes of unglazed tile (Quarry and hand-made unglazed tile excluded). It is 6 square inches or more in facial area, except smaller sizes, which may be required to complete a pattern of the larger sizes. Unless specifically stated otherwise, pavers are ½ inch thick (minimum ⅜ inch thick) varying to a greater thickness for the larger sizes.

NOTE.—These sizes are usually shipped unattached to paper and laid individually.

Unglazed tile having either an impervious, vitreous or semi-vitreous body is suitable for interior or exterior use subject to freezing temperatures in the presence of water.

Porcelain Tile.—This designates a vitreous unglazed tile made from clay and other ceramic materials refined and usually intimately mixed by washing. Tile of this type is characterized by a fine-grained dense body, sharply and precisely formed edges, and a smooth face impervious to stains. It is easily cleaned.

The color of the body, except white, is secured principally by the admixture of mineral oxides and stains. This tile is available in white, black and various colors, having either a plain, mottled or flashed face. The color effects, excepting red, are generally brighter, clearer and purer than those of other types of unglazed tile.

NOTE —If white or very light colors of unglazed tile are desired, specify "Porcelain" type so as to be sure of the non-staining qualities of the lighter colors.

The names of tile of this type are:

Porcelain Ceramic Mosaic.—Symbol PCM. Designating tile within the Ceramic Mosaic sizes described herein.

Porcelain Pavers.—Symbol PP. Designating tile within the Paver sizes described herein.

Natural Clay Tile.—This designates unglazed vitreous or semi-vitreous tile made principally from clays and shales and to lesser degree, other ceramic materials which are usually mixed together without washing and are formed by either pugging, cutting or pressing.

Tile of this type is characterized by precisely formed face and edges, and a dense body with a granular structure. The face of the tile presents a somewhat rugged surface, which is rough enough to minimize slipping and yet sufficiently smooth to be readily cleaned.

The color of the body is secured principally from the natural firing colors of the clays. This tile is available in various colors, but principally in black, reds, browns, tans, grays or blends thereof having either a plain, mottled or flashed face.

The names of tile of this type are:

Natural Clay Ceramic Mosaic.—Symbol NCM. Designating tile within the Ceramic Mosaic sizes described herein.

Natural Clay Pavers.—Symbol NCP. Designating tile generally over 6 square inches in facial area and otherwise within the Paver sizes described herein.

Abrasive Tile.—This designates an unglazed tile of either the Porcelain or Natural Clay type with an admixture of approximately 5 per cent by weight of abrasive grain (such as carborundum or alundum).

By reason of the abrasive grain, tile of this type is characterized by a coarse, rugged face, extremely resistant to slipping. The face and edges of the tile are rugged, but reasonably straight. The abrasive grain is thoroughly impregnated within the body of the tile. The surface can be readily cleaned.

This tile presents a speckled effect resulting from the interspersed abrasive grain showing on the surface of the tile.

The names of tile of this type are:

Abrasive Ceramic Mosaic.—Symbol ACM. Designating tile within the Ceramic Mosaic sizes described herein.

Abrasive Paver.—Symbol AP. Designating tile within the Paver size described herein.

Glazed Ceramic Mosaic Tile.—Symbol GCM. This designates a tile within the limits of the sizes of Ceramic Mosaic, as described herein. It may be glazed with either a transparent, white, block or colored glaze, or with polychrome and mottled effects thereof. The body may be either the Porcelain or the Natural Clay type, and is usually the general color of the glaze applied thereon.

Quarry Tile.—Symbol QT. This designates an unglazed tile made entirely or principally from clay and shale, or mixtures thereof. It is usually formed in the plastic state by extrusion or pressing.

Tile of this type is characterized by a dense body and usually has the somewhat rugged appearing face which is characteristic of larger sized tile mechanically formed in the plastic state. However, the face and edges are reasonably straight and smooth, and are readily cleaned.

The color is secured principally from the natural firing colors of the clay and shale used. The colors are principally red, buff, gray and blends thereof with either a plain or a flashed face.

This tile is, unless specifically stated otherwise, a minimum of ½ inch thick, varying to greater thickness to meet manufacturing convenience. It is generally larger in facial area than 6 square inches, but smaller sizes may be furnished as part of a pattern of the larger sizes.

Hand-Made Unglazed Tile.—Symbol HMU. This designated an unglazed tile which is formed while in its plastic state. The body is composed of clay principally, and to a lesser degree, other ceramic materials, prepared or blended by individually convenient methods.

The appearance of this tile is characterized by a rugged individual, although artistic variation of face and edges like that occurring in handicraft methods of forming and finishing in the plastic state.

The tile is a minimum of ½ inch thick, varying to greater thickness to meet manufacturing convenience. It is generally larger in facial area than 6 square inches, but tile of smaller size is furnished if needed as part of a pattern of larger sizes.

This type of body is adapted to, and widely used for, manufacturing special architectural shapes or designs having an unglazed finish.

CHAPTER 85

Tile Setting

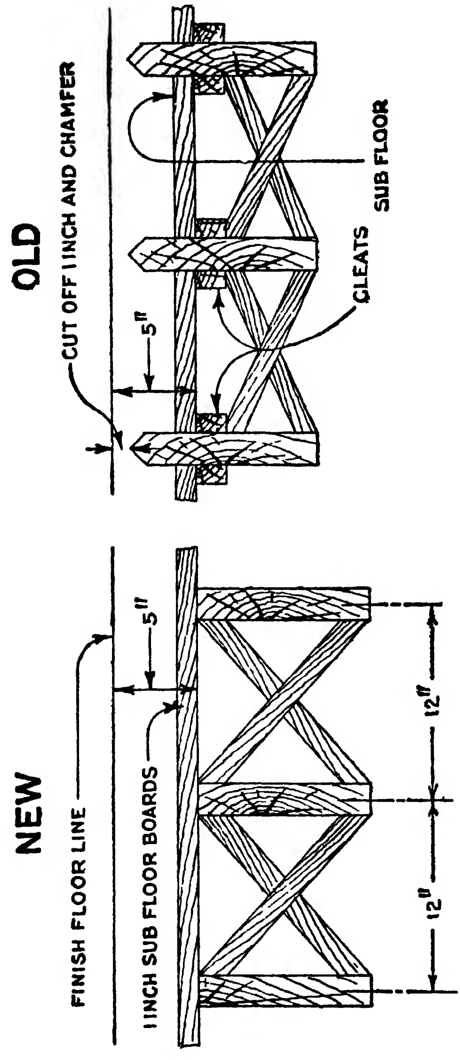
The author is indebted to Mr. C. R. Taylor, prominent authority on tile and tile setting, for valued assistance in securing the photographic views shown in this chapter, also similar views in the chapters on bricklaying and plastering. All these views were posed and photographed especially for this work.

In old buildings cleats should be nailed to joists 5 ins. below intended finishing floor line and short pieces of boards (not over 6 ins. wide) ⅛ in. apart fitted in between joists upon the cleats as shown in fig. 4,842. These boards should not be nailed but the joists thoroughly bridged. The boards should be cut for a loose fit against joists to allow for swelling.

To prevent an uneven foundation, the tops of the joists, when strong enough, should be chamfered off to a V-shaped edge as shown in fig. 4,842. When strong enough, an inch or more should be cut off the tops of the joist before chamfering as indicated, to give an even foundation; thus reducing the bearing and the chance of cracking in case of settlement.

Having completed the foundation, as in figs. 4,841 or 4,842, it should be covered with a layer of roofing paper to protect it from moisture of concrete and prevent dripping through to ceiling below. In the case of new work the paper is placed on the sub-floor. For old work with a foundation as in fig. 4,842, the roofing paper should be placed over the boards and carried up the joists; separate pieces shall then be put closely over the joists and overlapping those on the boards.

Concrete Setting Bed.—Having prepared the foundation as in figs. 4,841 and 4,842 and covered it with roofing paper, the next operation is the laying of the concrete setting bed. Place on the foundation two *guide strips* of a thickness equal to the



FIGS. 4,841 and 4,842.—Method of preparing foundation for tile floor in new and old buildings.

thickness of the concrete setting bed. Spread out the concrete over the space between these strips and true up the surface by working a *straight edge* across the screed strips as shown in fig. 4,843.

In the case of old work where the top of the concrete setting bed comes flush with the tops of the joists or a little below the guide strips are not necessary because the tops of the joist may be used as a base upon which to rest the screed strips in truing up the mortar setting bed. In large rooms it will be necessary to lay the beds in sections

Reinforcement.—In old work especially, it is advisable to place a reinforcement of wire netting on top the concrete setting bed, as in fig. 4,844.

This netting should be stretched tightly and fastened at the ends. When the bed is thus reinforced it will tend to counteract volume changes within the mortar as well as distribute strains.

Mortar Setting Bed.—On top of the concrete setting bed and the wire reinforcement is placed the mortar setting bed, also known vulgarly as "mud," or float coat. This is the

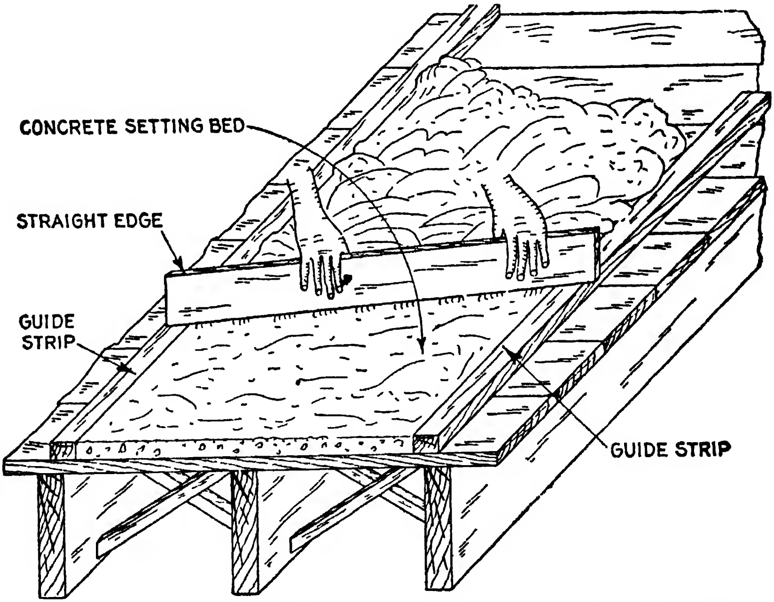


FIG. 4,843.—Method of laying concrete setting bed to uniform depth by means of levelin gwith gauge strips and straightedge.

setting bed on which the tile are placed or "floated," hence the name "float coat."

The cement mortar for this bed should consist of 1 part Portland cement and 3 parts clean washed sand, thoroughly mixed. Cement mortar must

be used while fresh, before it reaches its initial set. The mortar setting bed should not be less than ½ in. thick, preferably more.

In laying the mortar setting bed, the surface of this bed since it is in contact with the tile, should be at a level below

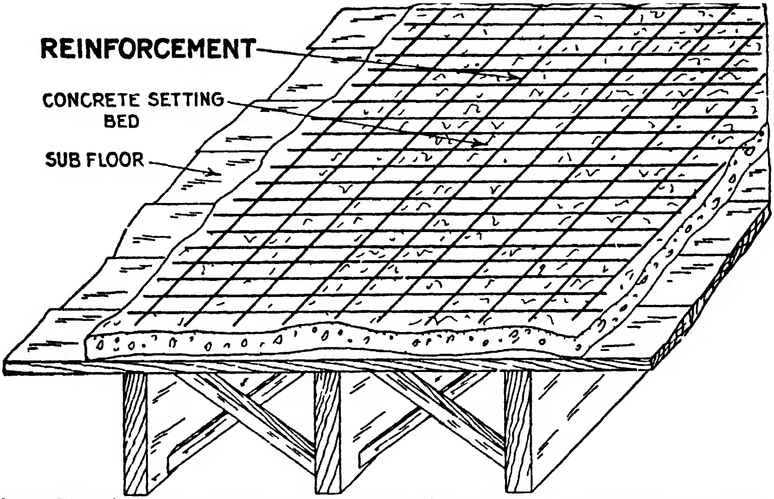


FIG 4,844 —Approved construction of placing a reinforcement, usually wire netting, on top the concrete setting bed to distribute the stresses and prevent cracking of the mortar setting bed

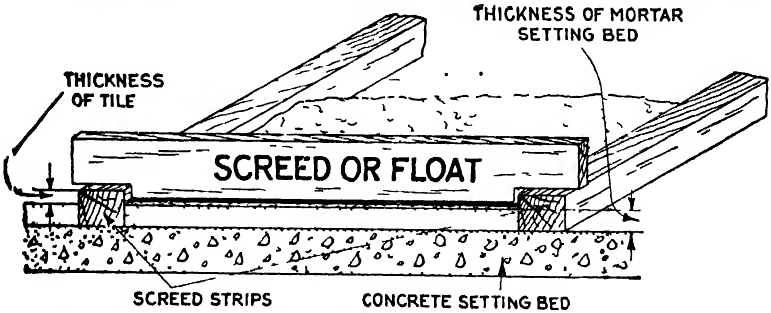
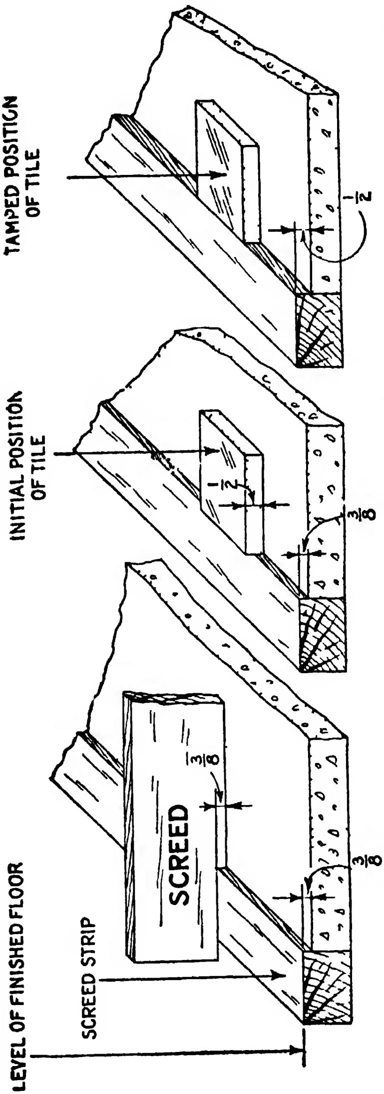


FIG. 4,845 —Screed or float in position on screed strips for leveling mortar setting bed on concrete setting bed The inside ends of the notches should be about 2 ins less than the distance between the inside edges of the strips and the notches cut to a depth ⅛ in less than the thickness of the tile.



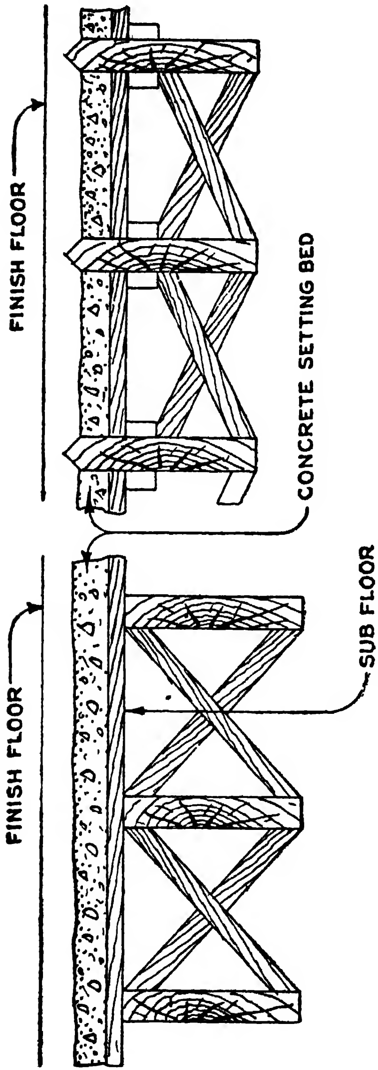
FIGS 4,846 to 4,848 —Enlarged detail of screed in position on screed strip showing 1/8 in margin for settling of tile in tamping, as illustrated in figs 4,847 and 4,848

the surface of the finished tile floor equal to the thickness of the tile.

Accordingly allowing 1/8 in for tamping down in floating the tile, the level of the mortar coat would be 3/8 in below the level of the finished floor if tile 1/2 in thick were used In order to bring the mortar setting bed to the right level for laying the tile, use is made of screed strips and a screed as shown in fig 4,845

The strips as seen in the illustration rest on top of the concrete setting bed Since the top surface of these strips represent the level of the tile floor, their thickness should equal the distance between the level of the concrete setting bed and the surface of the finished tile floor, and hence the necessity of leveling the surface of the concrete setting bed

The screed or float is a straight edge cut away at the ends to a depth equal to the thickness of the tile less 1/8 in margin for sinkage due to packing down the mortar when tamping the tile in floating This relation is shown in the enlarged view figs 4,846 to 4,848.



FIGS. 4,849 and 4,850.—Foundation for new and old buildings with concrete setting bed laid.

For a very small room the mortar setting bed may be laid in one operation, but for larger areas it should be done in sections or "units," as indicated in fig. 4,851.

When the tile are all of the same kind the unit or section may be of any convenient size, but for figured or fancy work the design will fix the size of the unit.

In setting the strips make a trial layout of a unit of the tiles as shown in fig. 4,851 which will give the proper spacing of the strips.

After securing the strips in position the tile are removed so that the mortar may be placed for setting the unit.

In fig. 4,851 note the margin left for border. With screed strips in position, dump in some mortar.

It is distributed over the area bounded by the screed strips by means of a rectangular trowel such as shown in fig. 4,853.

The distribution of the mortar to an approximate level surface is accomplished by three operations known as: 1, breaking down; 2, spreading; and 3, troweling, shown in the accompanying illustrations.

After thus working the mortar to the approximate surface it is leveled with the screed as shown in fig. 4,854.

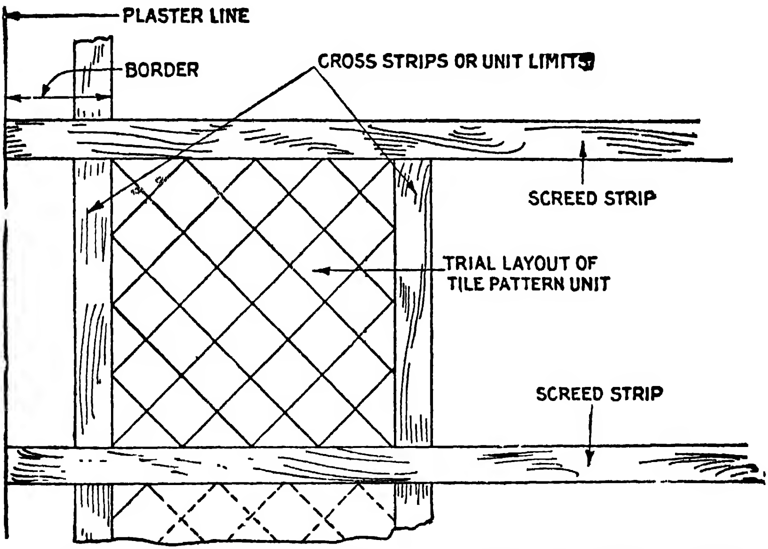


FIG. 4,851.—Unit method of placing screed strips in laying tile over large areas, unit at a time.

Unless the mortar setting bed be spread the same day, or a day after the concrete setting bed has been laid, the latter should be thoroughly saturated with clean fresh water before dusting with cement and spreading the mortar of the mortar setting bed.

Setting the Tile.—Before laying tile, dry cement should be

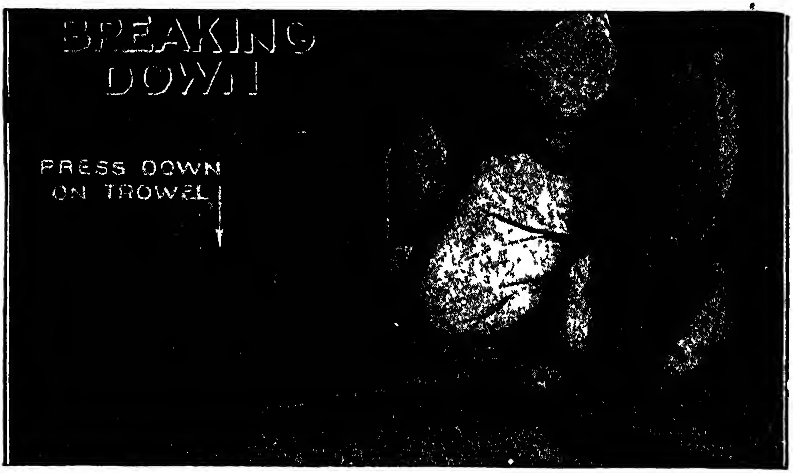


FIG. 4,852.—Breaking down

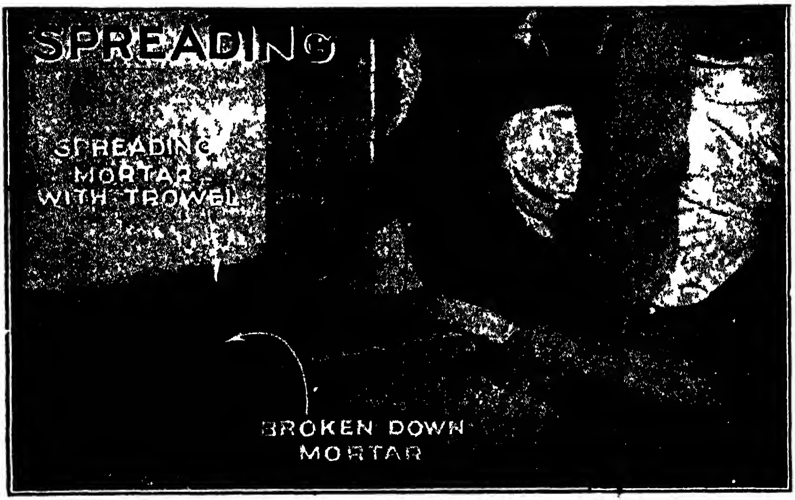


FIG. 4,853.—Spreading.

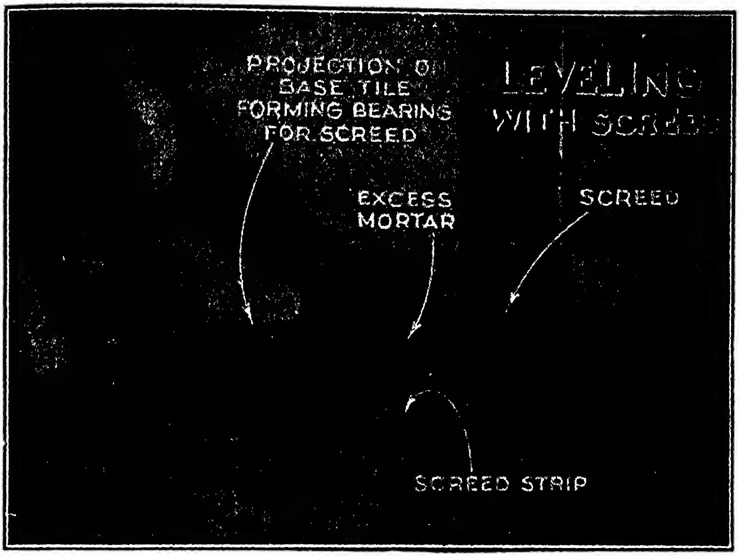


Fig. 4,854.—Leveling with screed.

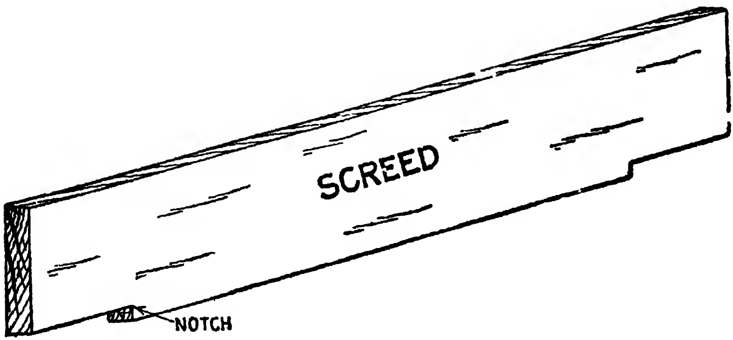


Fig. 4,855.—Screed.

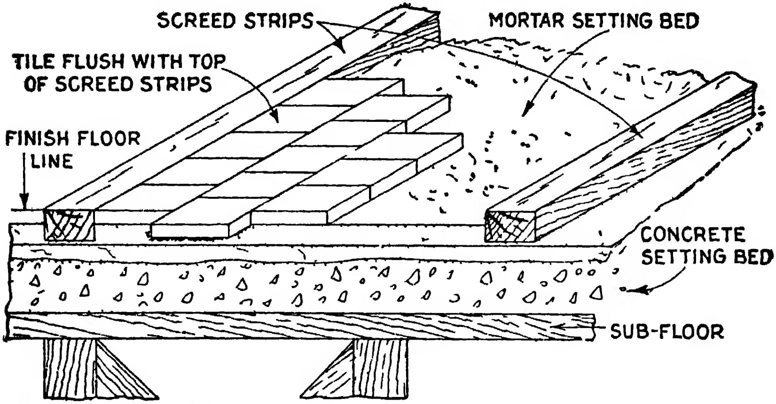


FIG 4,856 —Screed strips or gauge of finished floor surface placed on top of concrete setting bed, showing mortar setting bed and a few tile in place the top surface of the tile being flush with top of screed strips

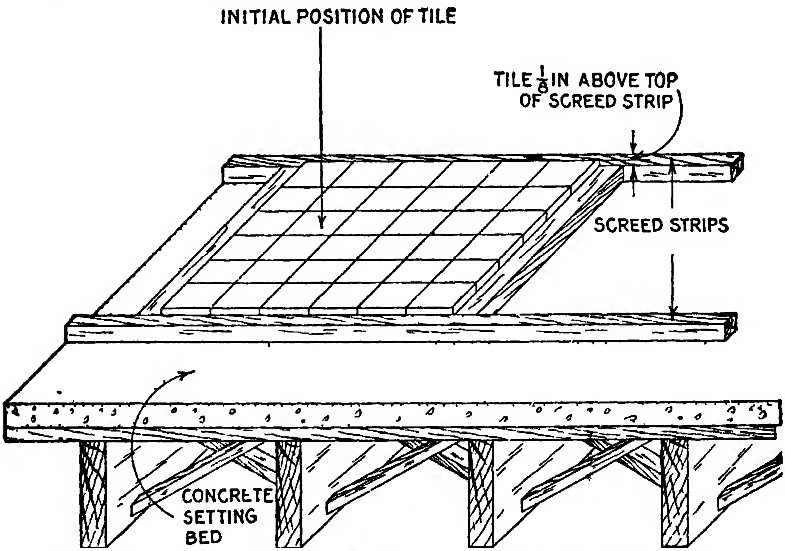
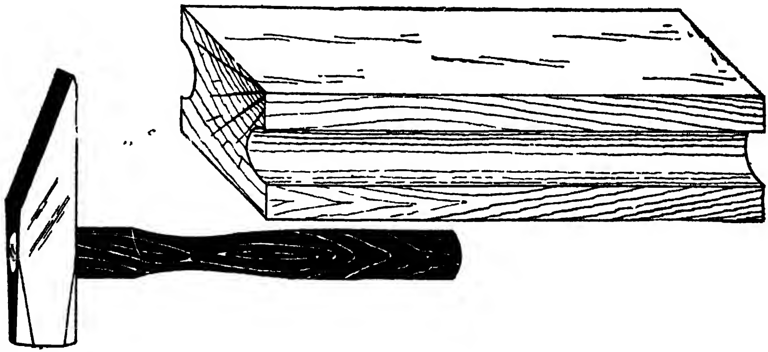


FIG 4,857 —One unit with tile placed, showing tile in initial or floating position ⅛ in above top of screed strips

dusted over the mortar setting bed to a thickness of about $^1/_{16}$ in., and all tile except vitreous should be thoroughly soaked in clean water. Begin laying a row of tile against one of the screeded strips, and use a half tile when beginning the next row to get the proper lap. If the tile has been cut, place the uncut or smooth edge against the screed strip, the cut edge facing the opposite direction. Any tile requiring lateral adjustment after being placed should be moved by inserting the blade of the trowel.



FIGS. 4,858 and 4,859.—Beater and beating hammer.

After filling up the space bounded by the screed strips with tile as in fig. 4,857, true up the joints by drawing the trowel along them as in fig. 4,861.

Beating In.—Fig. 4,857 shows the tile "set," that is, simply laid on top the mortar bed. As previously explained, the mortar setting bed is leveled off ⅛ in. higher than its final height to allow a margin for forcing the tile firmly on the mortar and packing the latter.

As seen in the illustration, the tile after being placed on the mortar, that is in their initial position project ⅛ in. above the top of the screed strips. They are brought down to their final position flush with the screed strips

by the process of beating in, using a beater and beating hammer as shown in fig. 4,860.

Since the tile do not touch each other but are separated by joints at least the thickness of the trowel blade, it is necessary before beating in, to lock the tile in position, to prevent them

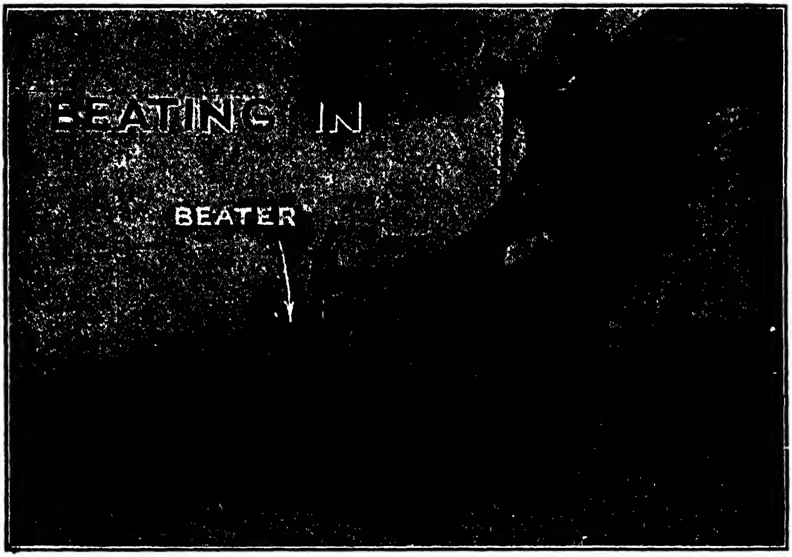


FIG. 4,860.—Beating in. This is done with the beater and hammer manipulated as here shown. The process is similar to beating in type in a form. In beating in, move the beater gradually over the entire surface hammering with the beater at the same time. If a tile persist in staying up or fall below the true surface, remove it with the pointing trowel and remove or insert mortar respectively.

shifting and spoiling the alignment of the joints, also to preserve the joint so that there will be room for grouting.

The width of the tile joints (which should be considered when placing the screed strips) varies for different kinds of tile as follows:

Vitreous and semi-vitreous tiles......1/16 in.
Float and hydraulic tile.............3/16 "

Plastic tile and faience..............¼ " in.
Quarry tile... . . ..½ "

To lock the tile in position, preliminary to beating in, scatter a handful of cement and fine sand mixed dry in equal quantities over the surface of the tile. Brush this into the joints, being careful not to displace any of the tile. This

Fig. 4,861.—Truing up or troweling the joints after setting the tile.

mixture filling up the joints holds the tile in position while they are being embedded in the mortar setting bed by the beating in process.

Rubbing with Beater.—After the tiles have been brought down to the true surface, they should be brought into thorough

contact with the mortar by rubbing with the beater so the mortar will properly adhere to the tile. This operation is known as "getting the tiles working."

Cleaning or Mopping Up the Tile.—Before applying the straight edge test, the surface of the tile should be thoroughly

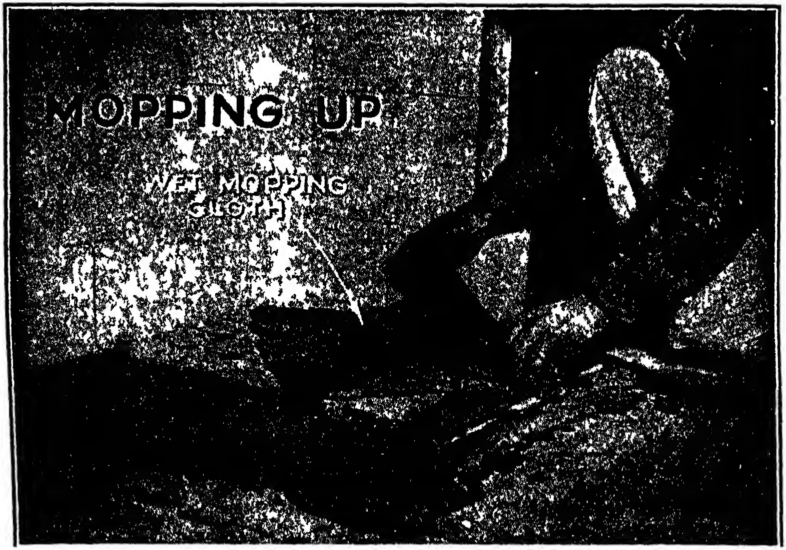


FIG 4,862 —Cleaning or mopping up the tile after beating in The reason for this operation is to prevent the straightedge being displaced by any bit of mortar or dirt that may be clinging to the tile surface A spirit level may be used but the straightedge extending to the screed strips is preferable

cleaned by drawing a piece of canton flannel or cotton blanket which has been saturated with clean water over the tile, as shown in fig. 4,862. The operation should be continued until the surface is clean.

Straight Edge Test.—After mopping up, the surface is in

condition for testing for alignment with the straight edge. If the tile have been beaten in to the proper level, the straight edge will be in contact with the tile surface and both screed strips. Any high or low spots are at once detected by this test, which is made as in fig. 4,863.

Grouting.—The operation of filling in the joints between

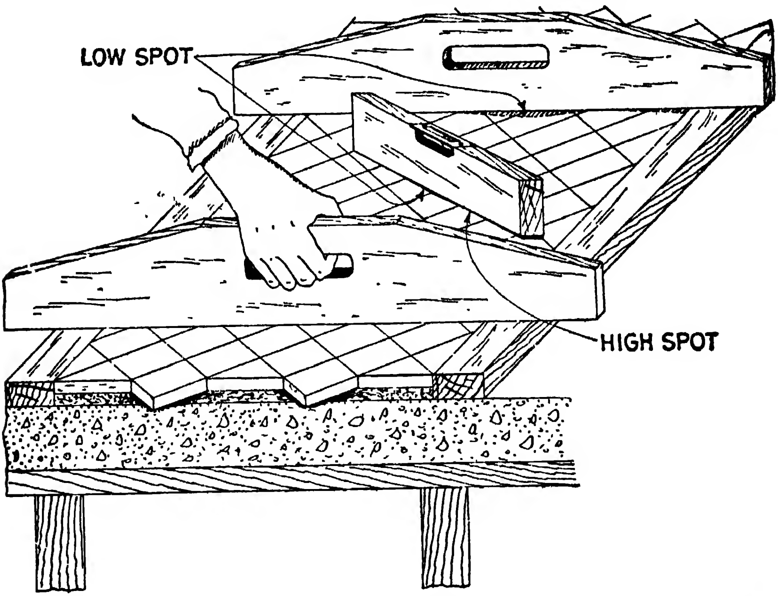


FIG. 4,863.—Straight edge and spent level tests for alignment of tile surface with the screed strips. In using the spent level, the faces of screed strips must be at the same elevation.

the tile with cement is known as *grouting*. Preliminary to doing this, the material previously placed in the joints to lock them in position while beating in must be removed. Remove this material with a whisk broom, stiff bristle brush or fine wire brush, thoroughly brushing out the material. The

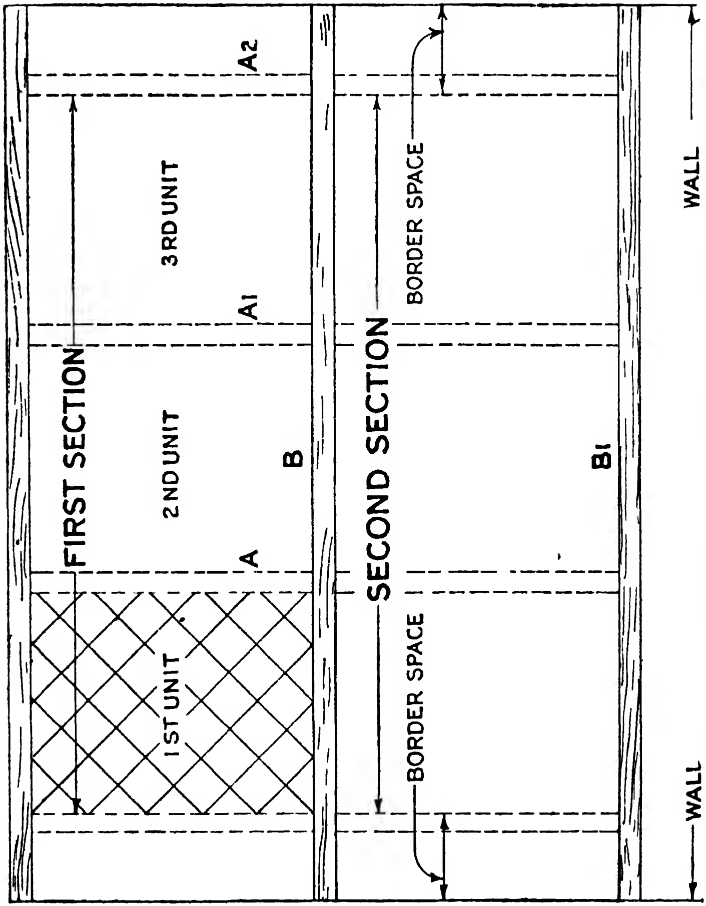


FIG 4,864 —Laying tile floor unit by unit and section After laying the first unit, cross strip is moved from position A, to position A_1, and A_2, for laying 2nd and 3rd units respectively After thus completing the first section screed strip B, is moved to position B_1, for the second section and so on until the entire floor area is covered, or in case of a border, the area within the border as shown

grouting mortar should consist of 1 part Portland cement and 2 parts sand.

It is permissible, if desired, to temper the mortar with hydrated lime, in quantity not more than 10% of the volume of the cement and sand. Make the consistency of the mixture that of soft butter.

To apply the grout, pour it over the tile and work it thoroughly into the joints with a brush. After working in, scatter dry cement over the tiled surface and work joints flush by scraping with a straight edge board diagonally across the surface.

Clean surface by repeating the mopping up process and rub sawdust diagonally across the joint with the palm of the hand to remove the last traces of grout from the surface of the tile.

Setting the Remaining Units.—Having completed the first unit as just described, remove one of the cross screed strips, and place in position at proper distance for setting the next unit as indicated in fig. 4,864.

Laying Ceramic Mosaic Tile.—This kind of tile is only ¼ in. thick and less than 2¼ sq. in. in area. They usually come pasted in units on paper, that is, the individual tiles or tesseræ are properly spaced and mounted on sheets of paper. Ceramic mosaic is the accepted collective term for these tiles and they are produced in a variety of sizes, shapes and colors.

The border of a ceramic mosaic floor should be laid before the center in the following manner: place short screed strips at right angles to the walls of the room and level with the finished floor line. Surface of leveling coat or concrete should then be saturated thoroughly with clean water. Sprinkle dry cement over concrete to a thickness of about 1⁄16 in.—as shown in fig. 4,865.

With a trowel spread cement mortar between strips as evenly

as possible for a width slightly exceeding that of the border. Put a screed edgewise over strips and with a sawing motion distribute and smooth out the mortar till it is even with the strips. Sprinkle dry cement over the mortar to a thickness of about 1/16 in. Mark the inner edge of the border on the mortar

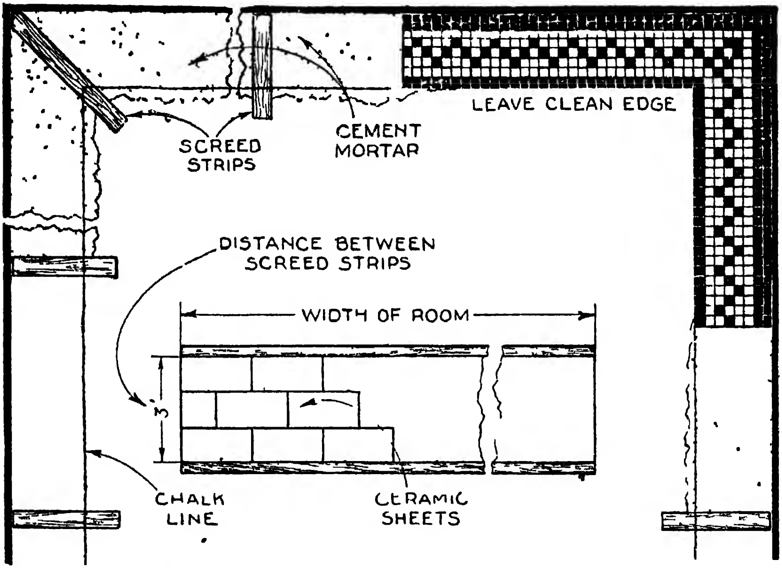


FIG 4,865 —Method of laying Ceramic Mosaic tile

with a chalk line. Remove the screed strips, fill grooves with cement mortar, and proceed with laying the border as described below.

Inner edge of border must be kept straight and all cutting of tile for irregularities in the wall line shall be done along the outer edge. Any cement mortar extending beyond the inner edge of the border shall be removed before hardening.

Field of the floor and floors without borders should be laid as

follows: set screed strips across the room and level with the finished floor line. Thoroughly saturate the leveling coat or concrete with clean water. Sprinkle dry cement over concrete to a thickness of about 1/16 in. With a trowel spread cement mortar between screed strips as evenly as possible. Put a screed edgewise over strips and with a sawing motion distribute and smooth the mortar till the entire surface is true and even with the strips. The larger the area thus covered, the better, provided the sheets of ceramic mosaic can be laid on it before the mortar reaches its initial set. Remove the screed strips and fill the grooves with cement mortar. Sprinkle dry cement over the mortar to a thickness of about 1/16 in. The sprinkling of dry cement shall not be done over the entire setting bed at one time, but shall proceed with the laying of the sheets.

Lay sheets of ceramic mosaic carefully on the mortar. Care must be taken to keep the joints between sheets the same general width as those between the mounted tile; the finished floor must not show where the sections join. In large areas of floor work, every third or fourth row of sheets shall be laid to a straight edge in order to avoid irregularities in the lines and design of the work.

Beat the tile down until the mortar shows in the joints through the paper, however, without breaking the paper. The paper shall then be moistened, and when well soaked, removed by carefully pulling it off backwards, starting with a corner. After removing the paper, sprinkle the tile with a dry mixture of white sand and cement in equal parts before finishing the beating, so that the tile will not adhere to the beater. Corrections of surface shall then be made by leveling with block and hammer.

Where the laying of the entire floor cannot be finished on the same day, the last row of ceramic mosaic including the cement mortar shall be cut off (to be replaced before laying is continued), leaving the finished part of the work with a clean beveled edge.

Joints should be grouted with Portland cement mixed with water to the consistency of cream. Force the grout into the joints with a flat trowel or thin board (not with a broom which often scrapes out the joints). After

dry cement has been sprinkled on the floor remove all surplus of the grout with sawdust and excelsior or bagging. All ceramic mosaic laid on one day should be grouted not later than the following morning to insure a proper bond between the grouting and cement mortar

Wall Tiles Placed on Studding.—When tiles are placed on studding, the studs should be framed 16 in. centers, thoroughly braced to prevent vibration and covered with expanded metal lath as shown in fig. 4,866.

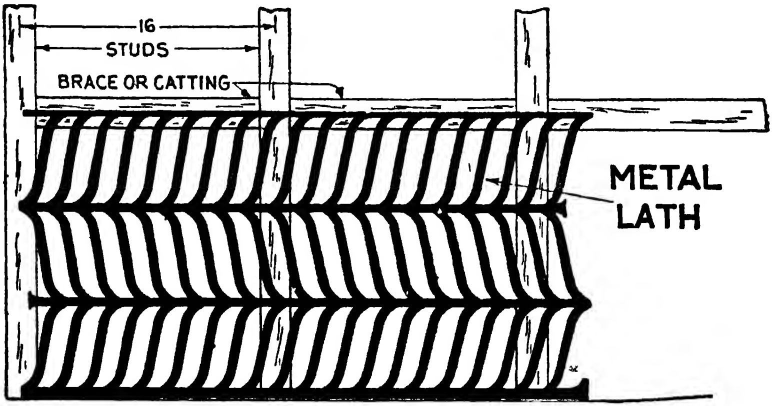


FIG. 4,866.—Metal lath placed on lath and forming a foundation for wall tile.

Setting Wall Tile—For vertical work, the setting is done by one of two methods known as

1. Floating.
2. Buttering.

These methods are described separately in the following sections.

Floating Wall Tile.—Soak wood laths of about 30 ins. length in water and then place them as guide strips on the wall to be tiled by putting a small amount of cement mortar on one side

of the laths. Apply plumb rule, and tap the laths against scratch coat until they are perfectly plumb, as in fig. 4,867. With a large brush thoroughly saturate scratch coat with clean water and then apply cement mortar with hawk and plastering trowel, bringing the coat of cement as nearly flush with laths as possible. Then use a float rod by placing it edgewise against the wood laths and "sawing" it from the bottom up until an

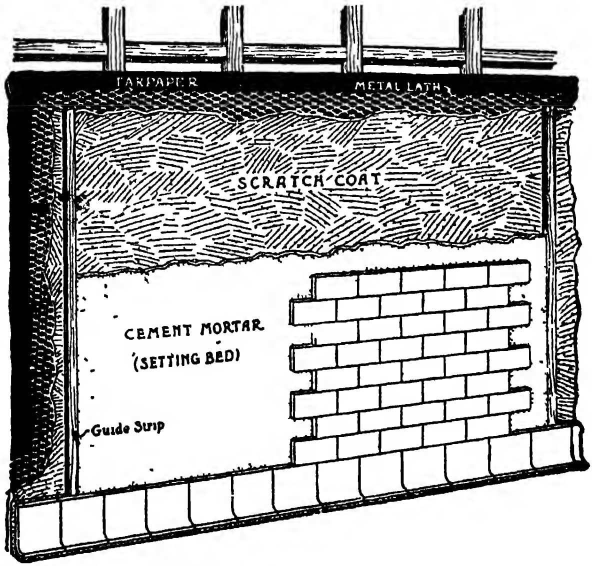


FIG. 4,867.—Method of setting wall tile by floating.

even coat results. Before placing tile on this coat, remove the wood lath guide strips and fill the grooves with cement mortar. Then mix a small quantity of pure cement, quite thinly, and apply a small amount on the back of each tile, place tile on the wall, and beat it carefully with block and hammer. Never rub face of tile with the block, since it will surely cause scratches.

Buttering Wall Tile.—After the base is set, wall shall be spotted about 30 ins. apart, with small pieces of tile (fastened with mortar) which must be absolutely plumb with face of finished wall.

These spots, as shown in fig. 4,868 are to act as guides to make the tile wall or wainscot perfectly plumb. With a large brush thoroughly saturate the scratch coat with clean water.

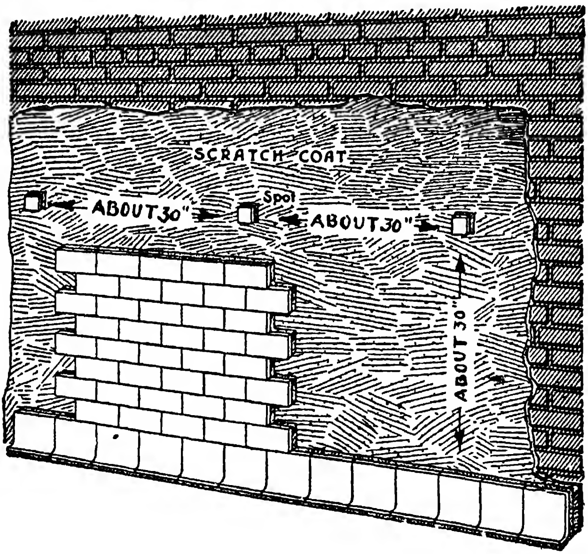


Fig. 4,868.—Method of setting wall tile by buttering.

Apply a small amount of clear Portland cement on the back of each tile. Spread the proper amount of cement mortar evenly on the back of each tile, place tile on the wall, and tamp gently until firmly united with the wall and plumb with the spots, frequently using a wooden straight edge which reaches

from lower course of tile or base to all the spots. Any tile projecting beyond or receding from the straight edge shall be tamped or brought out as may be necessary to insure a plumb and straight wall.

Every fourth course of tile shall be brought to a level and straight line by inserting small wooden wedges between the

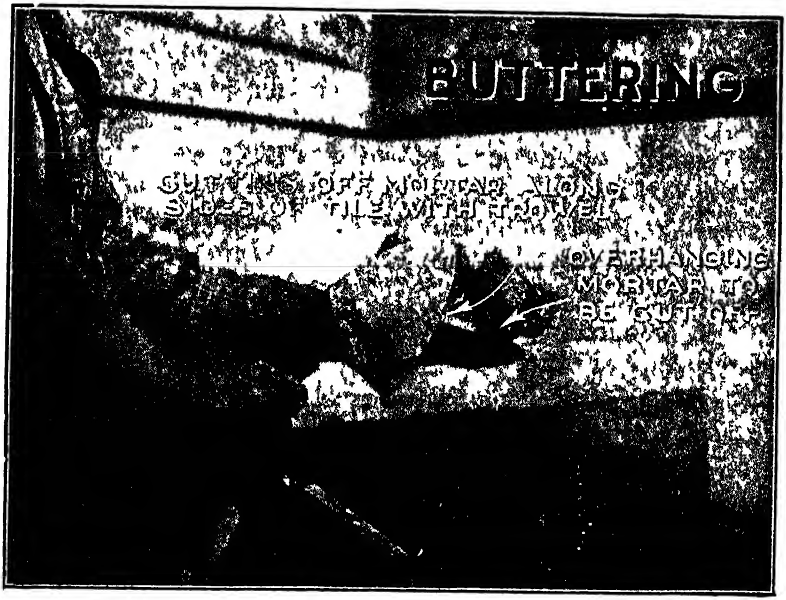


FIG. 4,869 —Buttering wall tile.

joints. These wedges are to be removed after tile is set and before grouting is done.

Doping.—In floating wall tile, what is termed *doping* should always be resorted to. After the cement mortar has been properly spread, take clear cement mixed to a creamy consistency

and spread thinly over the cement mortar bed with the flat trowel, then apply the tile.

It may have happened that the cement mortar bed, for some reason, has become soggy and inclined to sag. In this case use dry cement for doping, by dusting it evenly over the cement mortar bed. Another method of doping is by spreading the cement grout on a board, dipping into it the back of the tile, placing tile against the cement mortar bed, and beating in.

After the tile are properly set in place, the tile setter must see that his assistant thoroughly cleans out all joints, in order that grouting can properly be applied after the wall has become hard enough, which is usually by the next morning.

Terrazzo Floors.—By definition a terrazzo floor is a floor made of small chips or marble set irregularly in concrete and polished.

It is produced by laying mixtures of concrete containing marble chips or other aggregate of the desired color.

By adding coloring pigments a matrix of almost any shade or color may be obtained. White cement should be used for light shades and where clarity of color is important. After the concrete mixture has hardened for several days, the surface is ground and highly polished.

It is customary to use brass strips or strips of other suitable material to separate the colors of the desired pattern. These strips or separations also prevent cracks due to volumetric changes in the material.

The terrazzo course may be bonded to the structural base slab or may be separated by means of a sand cushion ¼ inch thick and a layer of tarpaper. Structural cracks which occur in the base slab will not be transmitted to the terrazzo top course if this is separated from the base.

An underbed of 1:4 mortar, 2 inches thick, is placed and the dividing strips are inserted in the mortar in the desired pattern. When this has hardened sufficiently, the terrazzo mixtures consisting of one part of Portland cement and two parts of aggregate are applied. The floor is then rolled until thoroughly compacted and after hardening sufficiently it is ground and polished.

The following specifications will be helpful in the preparation of aggregates and laying of terrazzo floors.

Color Pigments.—These shall be commercially pure, natural or synthetic mineral oxides or other coloring materials manufactured for use in Portland cement mixtures and proven satisfactory. The accompanying table may be used as a guide to the approximate quantities of high-grade pigments required for the colors and shades indicated.

Mixtures.—The base for terrazzo finish shall be mixed in the proportions of one part of Portland cement to four parts of clean, coarse sand. The terrazzo mixture shall be in the proportions of 200 lbs. of aggregate to one sack of Portland cement with not more than four gallons of water and the proper amount of pigment to produce the approved color. The cement and pigment shall be mixed dry to a uniform color before adding the other materials.

The terrazzo mixture shall be of the driest consistency possible to work into place with a sawing motion of the strike-off board or straightedge. Changes in consistency shall be obtained by changes in the proportions of aggregate and cement. In no case shall the specified amount of mixing water be exceeded.

PIGMENTS FOR COLORED CONCRETE FLOOR FINISH

Color desired	Commercial names of colors for use with cement	Approximate quantities required—lb. per bag of cement	
		Light shade	Medium shade
Greys, blue-black and black	Germantown lampblack*	½	1
	or carbon black* or	½	1
	black oxide of manganese*	1	2
	or mineral black	1	2
Blue	Ultramarine blue	5	9
Brownish red to dull brick red	Red oxide of iron	5	9
Bright red to vermilion	Mineral turkey red	5	9
Red sandstone to purplish red	Indian red	5	9
Brown to reddish-brown	Metallic brown (oxide)	5	9
Buff, colonial tint and yellow	Yellow ochre or	5	9
	yellow oxide	2	4
Green	Chromium oxide or	5	9
	greenish blue ultramarine	6	

*Only first-quality lampblack should be used. Carbon black is light in weight and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 lb. of oxide for each bag of cement.

Placing.—(*Method I—BONDED FINISH*).—The surface of the structural base slab shall be cleaned of all plaster and other materials that would interfere with the bond and shall be thoroughly wetted. It shall be slushed with a neat cement grout thoroughly broomed into the surface. The underbed shall then be spread uniformly and brought to a level not less than ½ inch nor more than ¾ inch below the finished floor.

Method II—BROKEN BOND FINISH.—The surface of the structural base slab shall be covered with a uniform layer of fine sand ¼ inch thick, and covered with an approved tar paper overlapping at least 2 inches at all edges. The underbed shall then be spread uniformly and brought to a level not less than ½ inch nor more than ¾ inch below the finished floor.

While the underbed is in a semi-plastic state, the dividing strips shall be installed to conform to the designs shown on the drawings. The top of the strips shall be at least 1/32 inch above the finished level of the floor.

The terrazzo mix shall then be placed in the spaces formed by the dividing strips and rolled into a compact mass by means of heavy rollers, adding aggregate if necessary so that the finished surface shall show a minimum of 70 per cent aggregate. Immediately after rolling, the surface shall be floated and troweled to an even surface disclosing the lines of the strips on a level with the terrazzo filling.

Curing and Protection.—All freshly placed concrete shall be protected from the elements and from all defacements due to building operations. As soon as the concrete has hardened sufficiently to prevent damage thereby, it shall be covered with at least 1 inch of wet sand or other covering satisfactory to the architect, and shall be kept continually wet by sprinkling with

water for at least 7 days when using standard Portland cement and for at least 3 days when using high early strength Portland cement.

The temperature of the concrete at time of placing shall be above 70° F. and it shall be maintained above 70° F. for at least 3 days or above 50° F. for at least 5 days when using standard Portland cement and above 70° F. for at least 2 days or above 50° F. for at least 3 days when using standard high early strength Portland cement.

Surfacing.—When the terrazzo concrete has hardened enough to prevent dislodgment of aggregate particles, it shall be machine rubbed, using No. 24 grit abrasive stones for the initial rubbing and No. 80 grit abrasive stones for the second rubbing. The floor shall be kept wet during the rubbing process. All material ground off shall be removed by squeegeeing and flushing with water.

A grout of Portland cement, pigment and water of the same kind and color as the matrix shall be applied to the surface, filling all voids. In not less than 72 hours after grouting, the grouting coat shall be removed and the surface polished to a satisfactory finish by machines using stones not coarser than No. 80 grit.

Cleaning.—After removing all loose material, the finish shall be scrubbed with warm water and soft soap and then mopped dry.

CHAPTER 85A

*Basic Specification for Tile Work

The basic specification gives in detail the specifications for tile installations in connection with practically every type of construction This is a composite specification that will cover tile installations in a small residence or a large office building. For example, certain paragraphs deal with the installation of tile on old wood construction These paragraphs have no bearing on the procedure of installing tile in a modern steel and concrete office building A basic specification should cover all conditions encountered and that is what has been attempted in the following sections

NOTES TO ARCHITECTS

This specification is written on the hypothesis that the tile contract will be awarded as a subcontract between the tile contractor and the general contractor

It is impossible to write a specification covering all types of work in all sections of the country without leaving some questions to be decided on by the architect Methods and practices vary in various sections, and different architects prefer different methods of accomplishing the same result. Section VII is intended to provide the architect with a checking list of the items not covered in the specification or on which the architect's decision is required

In writing a specification for a particular job, it is suggested that the single paragraph under Section VI be used and immediately followed by such modifications as the architect may find necessary after reading over the checking list

The first item to be covered in the actual specification is the scheduling of areas to be tiled, together with a description of the types and kinds of tile and accessories This item is not covered in this specification and is, therefore, first to assure attention of the architect The short form in Section VI, together with the modifications listed in Section VII, is all that is needed in the specification

For specificational data on tile work for swimming pools, subways, tunnels, etc., the architect is asked to call or write the office of the Tile Manufacturers' Association

NOTES TO TILE CONTRACTOR

The basic specification makes no mention of such items as scaffolds, hoists, water telephone, watchman, temporary heat, and light, storage, plaster-patching, insurance, or of general cleaning as distinguished from the initial cleaning of tile work

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*NOTE.—*The Basic Specification* for *Tile Work* is issued as a guide to *Architects, Contractors* and *Builders* by the TILE MANUFACTURERS' ASSOCIATION, INC.

Samples

(5) If so required, representative samples of each kind and type of tiles as specified and proposed for use shall be submitted by the contractor to the architect for approval, before proceeding with the work The approval of samples shall not be considered as modifying the requirements of these specifications, nor as relieving the contractor of his responsibility

(6) Each sample shall be plainly marked with the name of the manufacturer and the number and type of the tile Approved samples shall be retained by both the architect and the tile contractor

Grade

(7) All tile shall be of domestic manufacture and shall be STANDARD GRADE Where applicable, U S Department of Commerce Simplified Recommendation R 61 30 shall govern

(8) All grades of tile, other than STANDARD GRADE, proposed for use under this specification must be so specified by the architect

Minimum Requirements

(9) The minimum requirements, qualifications, standards of performance tests, and other standards relating to a particular kind or type of tile, or the grading of such tile, shall be in accordance with such minimum standards or revisions thereof as may be adopted by the tile industry

Certificate of Grade

(10) Before proceeding with the tilework, the tile contractor shall furnish the architect with a certificate of grade in the form adopted by The Tile Manufacturers Association, Inc This certificate of grade shall be signed both by the manufacturer and the tile contractor certifying to the grade type, and quantity of tile, together with adequate information for identification of the containers to which they apply

Containers

(11) All tile shall be brought to the work in the original unopened containers branded or labeled with the proper grade seal All containers shall be marked with designations corresponding with the information given on the grade certificates The containers shall be subject to inspection by the architect before being opened, as well as during the progress of the work

Section III

MATERIALS

General

(1) All materials used in the tilework shall be of an acceptable grade and quality and of domestic manufacture Cements and hydrated lime shall be delivered in the original containers, bearing the brand and manufacturer s name, and shall be stored in a dry place

Cement

(2) a All Portland cement (including white Portland cement and waterproofed Portland cement) shall be in accordance with A S T M Standard Specifications, Serial Designation C-9 38 or U S Government Federal Specifications, Symbol SS-C-191-a, with all subsequent revisions therein.

b All High Early Strength Portland cement shall be in accordance with the A S T M. Specifications, Serial Designation C-74-38, with all subsequent revisions therein

c All masonry cement shall be in accordance with the A S T M Tentative Specifications, Serial Designation C 91-38T or the U S Government Federal Specifications Symbol SS-C-181-b, with all subsequent revisions therein

Lime

(3) a All lime shall be of the high calcium type Dolomitic or high magnesium limes shall not be permitted Putty shall be prepared in accordance with A S T M Specifications, Serial Designation C 5 26, with all subsequent revisions therein

b All hydrated lime shall be in accordance with the A S T M Tentative Specifications, Serial designation C 6 34T, or the U S Government Federal Specifications, Symbol SS-L-351, with all subsequent revisions therein All quicklime shall be in accordance with the A S T M Tentative Specifications, Serial Designation C 5-34T, or the U S Government Federal Specifications, Symbol SS Q 341 with all subsequent revisions therein

Waterproofing

(4) All integral and metallic waterproofing material shall be of a quality and type approved by the architect

Sand

(5) a All sand shall be free from silt, loam, clay, soluble salts, or organic impurities, and be in accordance with A S T M Standard Specifications, Serial Designation C 40 33

b All sand shall consist of clean, washed, sharp, durable, uncoated aggregate free from all deleterious substances It shall be uniformly graded from coarse to fine with 100% passing through a No 4 mesh screen and not more than 5% passing through a 100-mesh screen.

c Sand for pointing mortars shall be in accordance with Paragraphs *a* and *b* excepting that 100% shall pass through a 30 mesh screen, and be uniformly graded from coarse to fine, with not more than 5% passing through a 100 mesh screen

Crushed Stone and Gravel

(6) Crushed stone and gravel for concrete fill shall be composed of clean, washed, sharp, durable, uncoated aggregate It shall be well graded from fine to coarse within the limits of 1/4" to 1' ring size and contain not more than 5% of fine clay, loam, or aggregate

Water

(7) All water used in conjunction with the tilework shall be clean, free from injurious amounts of oil soluble salts, chemicals etc.

Proportioning of Mortar Materials

(8) All materials for mortars should be carefull measured in their proper proportions, preferably on the volume basis

Preparation of Mortars

(9) Cement, lime, and aggregate shall be thoroughly mixed in the proportion hereinafter specified, to uniform color and required consistency Mortar *shall not* be retempered Tile *shall not* be set in mortar that has reached its initial set. All mortars shall be used only on the day mixed

Metal Lath

(10) a Metal lath shall be of the expanded type fabricated from sheet steel coated or cut from galvanized sheets, or fabricated from perforated metal, or shall be coated or galvanized wire lath Paper or fabric backed lath may be used provided half the strands of metal are imbedded in the mortar Metal lath shall provide continuous reinforcement in at least two directions transverse to each other

b Lath on vertical surfaces, where supports are not over 16 on centers shall be metal lath weighing not less than 3 4 lbs per sq yd, or wire lath not less than No 18 gauge (047 diameter) 2½ mesh to the inch Ribbed lath of the aforegoing weights shall be used on ceilings and on vertical surfaces when attached to steel studs and when the supports are not over 16' on center Flat lath shall not be used on ceilings or on vertical surfaces when the supports are over 12" on center

c Lath on vertical surfaces, where supports are placed not over 12' on centers, shall be metal lath weighing not less than 3 lbs per sq yd, or wire lath not less than No 20 gauge (035' diameter), 2½ mesh to the inch

d Vertical joints in lath shall be made at structural supports, and shall lap ½ inch at sides and 1 inch at ends of sheets, and shall be extended to the next adjoining supports at all corners No nailing shall occur at vertical internal corners Rib lath shall be nested at V ribs, and sheet lath shall have an equivalent lap

e Over old wood plaster walls, or other wall finishes the lath shall be welded wire mesh 2 x2" #14 gauge, expanded metal or metal lath, weighing not less than 3 4 lbs per square yard

Shrinkage Mesh

(11) a Shrinkage mesh for mortar setting beds shall be in accordance with Paragraph (10)e

b Shrinkage mesh where specified herein for use in concrete fill shall be 1 8# or 3 6# painted or unpainted expanded metal reinforcing, or wire fabric main members of which shall extend at right angles to the principal rib reinforcement and shall be spaced not more than four inches (4) center to center The cross members of the wire mesh shall be spaced not more than eight inches (8") center to center The sizes of all members in the wire mesh shall be not less than

For slabs 2 or less thick	No	10	W & M* gauge	(135)
" 2½ thick		9		(148)
" 3 thick		8		(162)
" 3½ thick		7		(177)

*Washburn & Moen Gauge also known as American Steel & Wire Gauge

Building Paper

(12) Building paper shall be either asphalt saturated paper weighing not less than fifteen (15) lbs. per 100 sq ft or shall consist of two sheets of sulphate kraft paper testing not less than 30 lbs. each (Mullen Test) cemented together with a layer of asphaltum, the completed sheet to weigh not less than 21½ lbs per 500 sq ft

Section IV

INSTALLATION

Preparatory Work, New Construction

(1) All grounds, door bucks, plugs, radiator hangers, plumbing, and other fixtures and fittings shall be in place, and all pipe trenches and chases or other openings in floor or walls shall be properly closed by others before the tile contractor proceeds with the preparation of walls and floors and the application of mortar for the tilework.

VERTICAL SURFACES

Wood Studding or Furred Construction

(2) a. Lath shall be stretched tight and shall be secured at all bearings with fastenings not more than seven inches apart, as follows: not less than one inch staple or one six-penny wire nail driven to a penetration of at least three-fourths inch before bending over In driving staples or nails, the lath shall not be flattened or damaged.

b. In shower compartments waterproof paper flashing shall be placed upon the wood studs at all interior angles, carried around the jambs and curb at door openings, and overlap the lead pan.

c. At all exterior angles a strip of waterproof paper shall be carried the height of the wainscot and returned at least four inches on the face of the studs.

d The architect shall indicate to the tile contractor the approximate location of all built-in accessories, prior to the placing of the scratch coat.

Masonry Construction

(3) a New unfurred surfaces of concrete or other masonry construction shall have been brought to the required plane, reasonably straight and true, by other contractors, with the faces free of fins, excessive voids, or projecting joints, and left fairly rough.

b All masonry construction shall be thoroughly cleaned and moistened directly before the scratch coat is applied

Gypsum Blocks, Cork or Other Insulation

(4) Furnish and place over the surface a layer of building paper; this in turn to be overlaid with stiffened expanded metal or sheet lath, or stiffened with lath as described in Section III, Paragraph 10, the lath to be secured to the gypsum block or other surfaces by special lacing, as conditions require, or in lieu thereof free standing metal firring may be used.

HORIZONTAL SURFACES

Wood Construction

(5) a. Where tile floors are to be laid over new wood floors, a layer of building paper, in accordance with Section III, Paragraph 12, shall be placed, properly lapped, and nailed

b When specified by the architect shrinkage mesh in Section III, Paragraph 11, shall be placed over the building paper This mesh shall be securely fastened in place, lapped and carried to all internal angles but shall not be turned up at the edges

Concrete or Other Masonry Construction

(6) The exposed surfaces of masonry floor slabs, arches, or other structural work shall be brought to the required level for the concrete fill or mortar setting beds *by other contractors*, and shall be free from mortar droppings, depressions, cracks, holes or joints When the mortar setting bed is to be applied directly upon a steel troweled or smooth concrete floor, the surface shall be hacked to provide a suitable bond

Steel Joist Construction or Pressed Steel Floor Systems

(7) With steel joist or pressed steel floor construction, the metal reinforcement and concrete slabs will be furnished and placed by other contractors as a part of such systems Mortar setting beds only shall be provided by the tile contractor and shall be placed directly on the concrete slab

Preparatory Work, Alterations

(8) All grounds, door bucks, plugs, radiator hangers, plumbing fixtures and fittings shall be in place, and all pipe chases or trenches or other openings in floors or walls shall be properly closed by others before the tile contractor proceeds with the preparation of walls and floors and the application of mortar for the tile work

VERTICAL SURFACES

Wood Studding or Furred Construction

(9) a The requirements in Paragraph 2 shall apply to this class of work

b All vertical surfaces shall be plumbed and placed in satisfactory condition by others, to receive the specified wall finish

Masonry Construction

(10) a Old surfaces of concrete, brickwork, or stone, when specified to be removed by others, shall have been hacked, roughened, or scored to provide a satisfactory bonding for the scratch coats

b New unfurred surfaces of concrete or other masonry construction shall have been brought to the required plane reasonably straight and true, by other contractors, with the faces free of fins, excessive voids, or projecting joints, and left fairly rough

c All masonry construction shall be thoroughly cleaned and moistened directly before the scratch coat is applied

Gypsum Blocks, Cork or Other Insulation

(11) The same requirements to be found in this section, Paragraph 4 shall apply to this work

HORIZONTAL SURFACES

Wood Construction

(12) a Where tile floors are to be laid over existing wood floors, the tile contractor shall cover the existing wood upper floor or under floor with paper in accordance with Section III, Paragraph 12, properly lapped and nailed

b When specified by the architect, shrinkage mesh in Section III, Paragraph 11, shall be placed upon the surface to be tiled This mesh shall be securely fastened in place, lapped and carried to all internal angles, but shall not be turned up at the edges

Concrete or Other Masonry Construction

(13) a. When required, existing terrazzo, cement, marble, or other type of floors shall be removed by others. The sub-floor shall be left clean and properly roughened to receive the mortar setting bed

b. When specified by the architect, shrinkage mesh in Section III, Paragraph 11, shall be placed upon the surface to be tiled This mesh shall be lapped and carried to all internal angles but shall not be turned up at the edges

Steel Joist Construction or Pressed Steel Floor Systems

(14) The same requirements to be found in this section, Paragraph 7, shall apply to this class of work.

Setting Beds and Installation of Tile

VERTICAL SURFACES

Scratch Coat

The total thickness of mortar, between the lath or sub-walls and tile, including scratch coat, plumb coat, and setting bed shall not exceed 1¼ inches.

(15) a The scratch coat as described herein shall be applied upon the metal lath or other properly prepared sub-walls, or other vertical surfaces to be tiled, by the tile contractor or by others

b The scratch coat mortar shall be in accordance with the Schedule of Mortar in Section V

c The scratch coat shall be at least 1/4" thick or more, if necessary, to make an even and true surface at the proper distance from the face of the tiles The scratch coat, at the option of the contractor, may be applied in two coats instead of one. While still plastic the scratch coat shall be deeply scored or scratched.

d The scratch coat shall be applied not less than 24 hours, nor more than 48 hours, before commencing to set the tiles

Plumb or Straightening-up Coat

This plumb or straightening-up coat may be omitted when walls have been properly straightened in the application of the scratch coat

(16) a The plumb coat or straightening up coat shall be at least 1/4" thick or more if necessary to make an even and true surface at the proper distance from the face of the tile

b The mortar for the plumb or straightening up coat shall be in accordance with the Schedule of Mortar in Section V The exact proportions of the plumb coat mortar shall be governed by the type of materials and conditions of the installation.

c The scratch coat shall be thoroughly moistened with clean fresh water immediately prior to applying the plumb coat.

d When tiles are set by the floating method screeds or temporary guide strips shall be mortared plumb and true onto the scratch coat to indicate accurately the surface plane of the plumb and straightening up coat

e The plumb or straightening-up coat shall be applied only in such quantity that will be covered with tile, not later than the day following, and shall be rodded and floated flush with the guide strips

Floating Method of Application

(17) a. The plumb coat or scratch coat shall be properly moistened before applying mortar setting bed.

b. The float coat mortar shall be as specified in the mortar schedule in Section V. The exact proportions of the float coat mortar shall be governed by the type of materials and conditions of the installation. It shall be applied only in such quantities as can be covered with tiles before the initial set of the mortar.

Buttering Method of Application

(18) a. The scratch coat shall be properly moistened prior to the installation.

b. The mortar used in the buttering method of application shall be as specified in the mortar schedule, Section V. The exact proportions shall be governed by the type of materials and conditions of the installation. The scratch coat shall be spotted with small pieces of tile mortared in place to indicate accurately the plane of the tile wall when finished.

Floating Method

(19) After the mortar setting bed has been floated flush with the guide strips, a skim of neat Portland cement shall be troweled to the mortar setting bed, or to the back of each tile unit, immediately before the tiles are placed.

Buttering Method

(20) Each tile shall be buttered with the setting mortar tamped in place and brought to a plumb and true surface flush with the spot and other tile. The back of each tile shall be covered with mortar to make the bed full and even.

General Requirements

(21) Vertical units and joints together with all caps, bases, and mouldings, shall be maintained plumb, level and even. Every fourth course or every sheet of mounted tile shall be brought to a level and straight line. All string and wedges used for jointing and spacing of the tiles shall be removed prior to grouting.

(22) All caps, bases, cove-mouldings, or other trim tiles shall be backed full with mortar.

(23) As soon as the mortar setting bed has sufficiently hardened, the tile on walls or other vertical surfaces shall be well washed with clean water prior to grouting.

(24) Where setting sheets of ceramic mosaic tiles, fill the joints with a moist filler of one part cement and one part sand. Then brush or trowel, upon back of each sheet a thin coat of neat cement paste.

(25) Where setting quarry tiles a butter coat of neat cement shall be applied to the back of each tile as laid. For tiles with a deep ribbed back, this butter coat shall be mixed in the proportion of one part of cement to two parts of fine sand.

(26) All tiles shall be firmly secured in place and beaten in with all finished surfaces brought to true and level planes. The completed work shall be free from cracked, broken or damaged tiles.

HORIZONTAL SURFACES

Mortar Setting Beds

(27) a. Before the mortar setting bed is spread, the concrete or masonry shall be thoroughly cleaned,

making sure same is free from dust or dirt accumulation, and shall be thoroughly moistened with clean, fresh water All excess water shall be removed.

b The mortar setting bed shall be as specified in the mortar schedule in Section V Mortar setting beds properly bonded to masonry sub-floors or reinforced with shrinkage mesh over concrete or wood sub-floors shall not be less than 3/4 inches in thickness. Mortar setting beds applied over wood sub-floors or concrete fill without the use of shrinkage mesh shall not be less than 1 1/4 inches in thickness.

c. The mortar shall be spread or screeded until the surface is true and even in plane, either leveled or uniformly sloped for drainage, as the case may be. As large an area as can be covered with tile before the mortar has reached its initial set shall be placed at one operation. When more setting mortar has been spread than can be thus covered, the unfinished portion shall be cut back to a clean beveled edge and removed.

Setting Floor Tile

(28) a. A light coating of Portland cement shall be uniformly hand-dusted or troweled over the surfaces of the mortar setting bed immediately preceding the setting of the tile. The setting bed shall be sufficiently plastic to wet properly the cement dust, but pools or excess water shall be avoided. Setting beds that have partially hardened shall not be softened with additional water The tile shall be placed upon and beaten into the mortar until true and even with the finished floor lines.

b. The tiles or ceramic mosaic sheets shall be laid to a straight edge at regular intervals

c. Wherever borders or defined lines occur, they shall be laid before the field or bodies of the floors or spaces to be tiled, and the tiles shall be set as before specified. The inner edges of all borders against fields or bodies shall be kept straight, and any cutting of tiles for irregularities in wall lines or vertical planes shall be done along the outer edges.

d. All surfaces not intended to be level shall be sloped as detailed or directed.

e. Tile nosing, coves, curbings, gutters, or other moulded or shaped pieces shall be thoroughly backed up with mortar. They shall be rigidly placed, reinforced, or otherwise made firm and secure.

f. The filler or spacing material in the joints shall be composed of one part Portland cement and not more than one part sand. As soon as the cement mortar beds have sufficiently set, the tiles on floors or other horizontal surfaces shall be washed with clean water and the joints between the tile grouted or pointed as specified in Paragraphs 32 to 34 of this section.

g. Joints between the tile units shall be in accordance with Paragraphs 29 to 31 of this section.

GENERAL PROVISIONS

Joints of Tile

(29) The joints between all units of ceramic mosaic and between the abutting sheets, as laid, shall maintain the standard mounting width.

Width of Joints

(30) Unless otherwise shown, specified, or stipulated in order to secure some special effect, the joints of other than ceramic mosaic tiles shall come within the limitations as scheduled below, with reasonable variations therefrom, as may be desired to cause the units, in the hands of skilled workers, to accommodate themselves to given spaces.

Schedule of Widths of Joints for Tile

(31)

SIZES	WIDTH OF JOINTS Floor	Wall
Mounted—2 3/16" square or smaller	1/16" to 1/4"	1/16" to 1/4"
Mounted—over 2-3/16 square	1/16" to 1/4"	1/16" to 1/4"
Unmounted—2-3/16' square to 4-1/4" square unglazed	1/8" to 1/4"	1/8" to 3/16"
Unmounted—6" x 6" & over unglazed	1/4" to 3/8"	3/16" to 1/4"
Quarry tile, unmounted	1/4" to 1/2"	1/4" to 1/2"
Glazed tile—3' x 3' 4 1/4' x 4 1/4', & 6" x 3		1/16"
Glazed tile—6" x 6', 9' x 6" & 12" x 6"		1/16" to 1/8"
Faience Tile—all sizes	1/8" to 1/2"	1/8" to 1/2"

Grouting and Pointing of Tile

(32) Mortar for grouting and pointing shall be as specified in Section V

(33) Grouting and colored mortars when specified or indicated, shall be prepared with non-fading mineral oxides used in quantities recommended by the manufacturer

(34) The grout or mortar for pointing all tile shall be forced into the joints by troweling, or some suitable method, and finished flush and true. When grouting glazed wall tile, special care shall be taken to prevent the scratching of the glaze All surplus grout or mortar shall be removed, before it has set or hardened, and the face of the tile left clean In the grouting of cushion edge tile, special care shall be exercised to remove any surplus cement by carefully wiping out joints both horizontally and vertically to the required depth

Accessories

(35) The furnishing and setting of accessories such as recessed heaters, paper holders, soap holders, towel racks, shelves, etc, are specified or scheduled as a part of the tile contract and listed in detail They shall be furnished and set by the tile contractor.

Borders and Patterns

(36) Where borders, lines, patterns, panels, or other effects are a part of the work, the tiles shall be properly spaced and shall accurately reproduce designs shown on the drawings or effects described in the specification of the architect.

Edges

(37) All intersections and returns shall be perfectly formed All cutting and drilling shall be neatly done without marring the tile The cut edge of tiles against any trim, finish, built in fixtures, etc, shall be carefully ground and jointed ' Around electric outlets, plumbing pipes, or fixtures and fittings, tile shall fit close, so that plates, collars or coverings will overlap the tile. No split tile will be permitted, except in those locations where pipes or trim make cutting necessary

Laying Out

(38) All tile work shall be so laid out on floors and lengthwise on walls that no tiles less than half full size shall occur For heights stated in feet and inches, unless tile work is intended to fill exactly vertical spaces, courses shall be maintained full to produce nearest attainable height within a variation above or below equivalent to less than one-half course to avoid cutting of tiles which would otherwise be necessary.

Soaking Before Laying

(39) All tile except non-absorbent tiles and those mounted on paper shall be thoroughly soaked in clean water before being set.

Tile Packages Kept Dry

(40) All tiles shall be kept dry while in packages.

In Freezing Weather

(41) In freezing weather no tile work shall be executed.

Removal of Condemned Tile

(42) Prior to the final acceptance of the tilework, the tile contractor shall, at his own expense, remove and replace all condemned tiles, except those damaged by others.

Cleaning

(43) a. Upon completion of the various portions of his work, the tile contractor shall remove all unused materials, rubbish, etc., that have accumulated as a result of his work.

b. After the pointing has sufficiently set or hardened, all tile on walls and vertical surfaces, or floors and horizontal surfaces, shall be thoroughly cleaned in an approved manner. All traces of cement or dust accumulations shall be completely removed. In cases where acid solutions are required to clean the face of the finished tilework of surplus grouting or mortar used for pointing, all exposed hardware shall be first covered by a heavy coating of vaseline to protect the metal from the possible effects of the acid or its fumes. *Acid solution shall not be used for cleaning glazed tile.*

c. The tile contractor shall give the tilework one thorough cleaning when so instructed by the general contractor or architect. After completion and cleaning the obligation of the tile contractor shall cease as to any damage or injury which may be done to the tilework by others, and as to any further cleaning of the tilework upon final completion of the building as a whole.

Responsibility

(44) Neither the final cleaning, payment, nor any provision in the Basic Specification shall relieve the tile contractor of responsibility for faulty materials or workmanship, and he shall remedy any defects due thereto which shall appear within a period of one year from the date of acceptance of the tilework, except those defects due to failure in the substructure.

Section V

MORTAR MIXTURES

(Quantity of materials in parts by volume)

Wall Installations

Scratch Coat

(1) Scratch coat shall be one (1) part Portland cement, and three (3) parts sand.

(2) Optional—Waterproofed Portland cement or not more than one-fourth (¼) part lime putty

or one-fourth ($^1/_4$) part waterproofed lime putty or integral waterproofing compounds (in proportions recommended by manufacturer) may be incorporated in the scratch coat mortar

Plumb or Straightening-up Coat

(3) The plumb or straightening-up coat mortar shall be one (1) part Portland cement, one-half ($^1/_2$) to one (1) part lime putty, and three (3) to four (4) parts sand.

Float Coat or Buttering Mortar

(4) The float coat or buttering mortar shall be one (1) part Portland cement, one-half ($^1/_2$) to one (1) part lime putty, and three (3) to four (4) parts sand.

(5) OPTIONAL—Waterproofed Portland cement, or waterproofed lime putty, or integral waterproofing compounds (used in proportions recommended by manufacturer) may be incorporated in the float coat or buttering mortar

Skim Coat

(6) The skim coat shall be neat Portland cement, mixed with clean fresh water

(7) OPTIONAL—Waterproofed Portland cement, lime putty, or integral waterproofing compounds (used in proportions recommended by manufacturer) may be incorporated in the skim coat.

Grouting

(8) Grouting for all joints one-eighth inch (1/8") or smaller in width shall be neat waterproofed Portland cement, a mixture of neat Portland cement and lime putty, or a mixture of neat Portland cement and integral waterproofing compounds (used in proportions recommended by manufacturer) Either white or gray Portland cement may be used. The grout shall be mixed with clean fresh water to the consistency of thick cream.

Pointing Mortars

(9) Pointing mortar for all joints (1/8" to 1/4") or smaller in width shall be one (1) part waterproofed Portland cement and one (1) part sand. Portland cement to which has been added integral waterproofing compounds (used in proportions recommended by manufacturers) or lime putty may be substituted for the waterproofed Portland cement.

(10) Pointing mortar for all joints greater than 1/4" in width shall be one (1) part Portland cement and two (2) parts sand. Portland cement to which has been added integral waterproofing compounds (used in proportions recommended by manufacturer) or lime putty may be substituted for the waterproofed Portland cement.

Floor Installations

Setting Bed

(11) Setting bed mortar shall be one (1) part Portland cement and three (3) to four (4) parts sand.

(12) OPTIONAL—Waterproofed Portland cement or not more than one-fourth ($^1/_4$) part lime putty or one-fourth ($^1/_4$) part waterproofed lime putty or integral waterproofing compounds (used in proportions recommended by manufacturer) may be incorporated in the setting bed mortar

Grouting and Pointing

(13) Grouting and pointing mortars shall be in accordance with Paragraphs 8, 9, and 10.

Section VI

SHORT FORM SPECIFICATION

Where the installation is to be in full accordance with the Basic Specification, *without* samples or *without* modification.

Furnish all materials and labor necessary for the completion of the tilework. The Basic Specification for Tilework, Fourth Edition, 1939, as issued by the Tile Manufacturers' Association, Inc, insofar as any portion is applicable to this building, is hereby made a part of this specification and of the contract

The kinds of tile and accessories and the extent of tilework shall be in accordance with the schedule as shown on the plans.

Note

1 *Should the Architect desire to modify this paragraph the following sentence should be added*—"This Specification shall be modified as follows"—(See Section VII)

2 Include any reference to other materials or labor furnished by the tile contractor as the Basic Specification is confined to tilework only

Section VII

MODIFICATIONS OR ADDITIONS

Modifications

Types and Location of Tile

(1) A schedule of the types and kinds of tilework and accessories, with the locations to be tiled, should be provided either in this specification or on the plans If the schedule is to be in the specification, it should follow at this point If the schedule is on the plans, a paragraph referring it to the contractor s attention should be inserted here.

Samples

(2) Section II, Paragraph 5 of the Basic Specification provides for the submission of samples "if provided in the architect's specification " If samples are desired, a note should be inserted stating whether the samples should be submitted with the bid or after the award of the tile contract.

Grade

(3) The Basic Specification provides that Standard Grade tile of domestic manufacture be used and a certificate of grade be furnished by the manufacturer All grades of tile, other than Standard Grade, proposed for use under this specification must be so specified by the architect

Cleavage Planes

(4) a. Some architects advocate the use of cleavage planes under the tilework on certain types of installations. The Basic Specification does not provide for the use of cleavage planes If this treatment is desired, a note to this effect should be inserted in the architect's specification. These

cleavage planes should be of sand or building paper and, if of sand, should be approximately 1/4" thick. A layer of building paper should be placed over this sand cushion.

b When cleavage planes are placed on concrete or other masonry construction shrinkage mesh as specified in Section III, Paragraph 11, shall be placed over the building paper The mesh shall be lapped, carried to all internal angles but not turned up at the edges

Buttering or Floating Method of Installation

(5) Section IV, Paragraphs 17, 18, 19, and 20, cover both the buttering and floating methods of installing tile. The method used by tile setters varies according to locality. The basic specification provides that either method may be used in the absence of stipulations to the contrary If the architect prefers one of these methods, he should so state in his specification.

Joints in Tile

(6) Section IV, Paragraph 31, provides for the usual width of joints in the tilework If a special effect is desired necessitating a change in the usual joint thicknesses, it should be noted in the architect's specification.

Gray or White Grouting

(7) Section V, Paragraphs 8, 9, and 10, provides for either gray or white joints. If the architect has a preference for one of these two it shall be noted in his specification.

(8) Section IV, Paragraphs 32 to 34, provides for grouting of tilework. If a special effect is desired necessitating joints other than white or gray, the color should be noted in the specification

Cinders, Slag, Clay, etc., Waterproofing

(9) No attempt has been made to include the use of cinders, slag, or clay in the mortars and concrete specified in the Basic Specification The type of those materials that can be obtained in the locality of the work governs their suitability for use. In the case of the use of special cements or the addition of waterproofing to the mortar setting bed, concrete fill, or the grout, there are so many special conditions to cover that no attempt has been made to provide a definite specification for this type of installation.

The architect should include in his specification any special provisions covering the above items

Responsibility and Cleaning

(10) It is suggested that the architect check Section IV, Paragraphs 43 and 44, of the Basic Specification as the statements and conditions covered therein may change with various jobs

Related Work

(11) An effort has been made to include in this section those items of related work that should be done by other contractors. These items are intended to serve as a checking list for the architect in the preparation of his specification. In making up this list consideration has been given to the fact that, while the tile contractor is equipped to handle some of these items, they can usually be done by either the general contractor or by other subcontractors. In some cases where there is no general contractor and the tile contractor assumes all of the work, it will be necessary to amend the short form tile specification to include these items. However, in these cases the question of union jurisdiction and allotment of work should be checked by the architect.

Carpentry, Floors—New Construction or Alterations

(12) *Proper framing for tile floors is necessary to prevent cracking or buckling due to the weight of the mortar bed, or flexure, shrinkage and warpage of the wood sub-structure.*

a. TILE OVER WOOD SUB-FLOOR

A most satisfactory job is the installation of a ¾" reinforced mortar bed directly over the wood sub-floor of the structure.

The wood sub-floor of not less than 13/16" thick by not over 6" wide boards shall be laid diagonally with the joists under the area to be tiled and securely nailed. Boards shall be tongue and groove or placed about ¼" apart. All loose, defective, exceptionally rough and uneven areas shall be eliminated.

b. TILE OVER SUB-FLOOR FLUSH WITH TOP OF JOISTS

This method permits the tile to finish flush with adjacent double wood floors.

Nailing strips 1"x2½" shall be fastened to the sides of the joists, under the area to be tiled, and the sub-flooring shall be securely fastened to the strips in such a manner that the surface of the sub-floor is level with the top of the joists.

c. COUNTER-SEALING AND CHAMFERING OF JOISTS

This method provides for a concrete fill under the mortar bed.

The floor joists shall be chamfered to a point ½" below the surface of the concrete fill and the floor counter-sealed by nailing cleats 1"x2½" to the sides of the joists, at a distance below the finished floor required for the construction of tile floors. Between the joists lay boards ¼" apart, securely nailed to the cleats.

Carpentry, Walls and Floors—Alterations

(13) The removal of old wood floors and old finish materials from the walls of areas to be tiled may be done by either the tile contractor or other trades. The decision on the following paragraphs should be based on the job conditions.

a. REMOVAL OF OLD WOOD FLOORS

By Other Trades or By Tile Contractor

Insert following paragraph in architect's specification under appropriate trade.

This contractor shall remove all wood flooring from areas to receive tile and shall place the sub-floor in a satisfactory condition to receive the tilework, free from rubbish, projecting nails, etc. He shall fill up all holes and openings.

b. REMOVAL OF OLD WOOD, PLASTER WALLS OR OTHER WALL FINISH MATERIAL

By Other Trades or by Tile Contractor

To be inserted in architect's specification under appropriate trade.

All old plaster, wood sheathing, or other finish materials on walls to receive tile shall be removed and the walls placed in sound condition.

NOTE. If the finished tile surface can be brought out at least ½ inch, plus tile thickness from the old wall, the existing wood, plaster, or other present wall materials need not be removed when in a sound condition.

Carpentry, Walls and Floors—New Construction or Alterations

(14) a. **Installation of Building Paper Over Old Wood Floors, Over Counter-sealed Joists, and Behind Scratch Coats**

NOTE. In paragraphs (16)c and (17) the installation of concrete fill and also the scratch coat is provided as either the work of the tile contractor or of others If others are to provide this fill or scratch coat, the following should be provided in the architect s specification under the appropriate trade:

This contractor shall provide an asphalt saturated paper weighing not less than 11 lbs per 100 sq. ft over the (floors), (counter-sealed joists), (behind wire lath to be installed on the walls) (*Strike out portions not applicable*)

b. SUPPLEMENTARY FRAMING BEHIND TILE WAINSCOTS

The Basic Specification provides that supports for metal lath be supplemented when spaced over 16" on centers, if such a condition exists. it is suggested that the architect provide for this supplementary framing or furring under the appropriate trade

Concrete or Other Masonry Work, New Construction

(15) NOTE: The two following paragraphs should be inserted in the architect s specification under the appropriate trade regardless of who supplies the concrete fill or the scratch coat

a Vertical surfaces of concrete or other masonry which are to be faced with tile shall be brought to the proper plane to receive the required thickness of scratch coat and tiles, and shall be made reasonably straight, with faces free of fins, projecting joints or excessive voids, and left fairly rough

b Horizontal surfaces of concrete or other masonry construction which are to receive tilework shall be brought to the required level or surface for the concrete fill or mortar setting beds and shall be free from mortar droppings, projecting joints, etc., and shall present comparatively smooth and even surfaces ready to receive concrete fill or mortar setting beds for tilework without any depressions, cracks, holes or open joints.

Concrete or Other Masonry Work, Alterations

(16) NOTE: The following paragraphs cover the preparation of masonry surfaces to receive tile

a. PREPARATION OF MASONRY WALLS

By Other Trades or by Tile Contractor

To be inserted in architect s specification under appropriate trade

Thoroughly wash and clean all concrete or masonry walls and floors with wire brushes and 10% muriatic acid and 90% water solution or approved equal The concrete or masonry floor and walls shall be thoroughly wet with water so that the acid will act on the surface only Make one to three washings, following each with a clean water rinse or washing to remove all traces of the acid Do not allow the acid solution to dry on the concrete or masonry Cement dust shall be removed Old or painted surfaces of concrete, brickwork, or stone shall be hacked, roughened, or raked to provide satisfactory bonding for the scratch coat.

b. REMOVAL OF OLD CEMENT, TERRAZZO, FLOORS, ETC.

By Other Trades or by Tile Contractor

To be inserted in architect's specification under appropriate trade

All old cement, terrazzo, floors etc, shall be removed under the areas to be tiled The surface shall be left at a proper level to receive the tilework and roughened and properly prepared

c. INSTALLATION OF CONCRETE FILL

NOTE In some cases the architect may wish to award the installation of concrete fill to other trades, then it will be necessary to have the work specified in paragraphs (13) a, (13) b, (14) a, and (16) b of Section VII done by the general contractor

By Other Trades or by Tile Contractor

To be inserted in architect's specification under appropriate trade

Concrete fill shall be placed upon the sub floor under the area to be tiled to bring its level to within at least two inches (2″) of the finished floor line It shall be at least two inches (2″) thick except that over earth fills it shall be three inches (3″) thick All floor slabs and all wood floors shall be [illegible] loose particles before placing any concrete fill Shrinkage mesh shall be installed in accordance with the requirements of the B[illegible] Specifications for Tile Work 1939 Edition, Section III Paragraph 11 Concrete shall consist of one volume of Portland cement two and one half volumes of sand and five volumes of gravel or crushed stone Concrete shall be spread promptly after mixing and shall be compacted to uniformly rough surface at proper level to receive setting mortar

d. STEEL JOISTS AND PRESSED STEEL FLOOR SYSTEMS

NOTE The Basic Specification provides that the concrete slabs and reinforcing mesh used in connection with this type of construction shall be placed by others A paragraph should be inserted in the specification of the trade affected covering this work

e. SHEET METAL OVER PROJECTING BEAMS

NOTE The upper flanges of any projecting steel beams should be covered with sheet metal to prevent any adhesion of the concrete fill. The Basic Specification provides that this work will be done by others.

Lathing and Plastering

(17) NOTE Practice in regard to the installation of the scratch coat varies in different sections of the country It is suggested that the architect read the definition of the term "scratch coat" as covered in Section II (Definition of Terms) In the Basic Specification the installation of the scratch coat is the responsibility of either the tile contractor or of other trades and the specification provides that the architect will state who is to handle this work The architect should modify the basic specification to state who will be responsible for this work.

a. SCRATCH COAT

When to Be Done by Other Trades

To be inserted in architect's specification under appropriate trade

Furnish and set metal lath and scratch coat back of all tiled walls or ceilings specified under tilework. All such metal lath and scratch coat work to be prepared for and done in accordance with the requirements of the Basic Specification for Tilework 1939 Edition Section IV Paragraph 15 The portions of this specification referring to the installation of metal lath and scratch coat shall be considered a part of this specification and this contractor should familiarize himself with these requirements

To be added to tile specification

The scratch coat and metal lath work is applied by others and is not a part of this contractor's work.

If to Be Done by Tile Contractor

To be inserted in architect's specification under appropriate trade

The metal lathing back of tilework is not specified as a part of this contractor's work as the same is specified under the heading of tilework

To be added to tile specification

This contractor shall install the scratch coat in accordance with the Basic Specification.

b. STRUCTURAL SUPPORTS

If pressed steel joists, or studs, or other forms of metal joists, studs, channels, tees or furring strips form the structural supports for any tilework, it is assumed that the architect's specification will provide that metal lath in connection with same shall be furnished and applied as a part of such construction The Basic Specification states that metal lath on this type of construction is not included as a part of the tilework See Section IV, Paragraphs 4 and 11

c. CONCRETE CEILINGS

If concrete ceilings or soffits are to be tiled, the scratch coat shall not be placed on unfurred concrete surfaces If ceilings are to be suspended, provision should be made for their construction including metal lath ready to receive the scratch coat

d. PLASTER PATCHING

The following paragraph should be inserted in the plastering specification as the responsibility for plaster patching should be definitely stated

Upon completion of the tilework, this contractor shall point and patch all joints between the plaster and tilework

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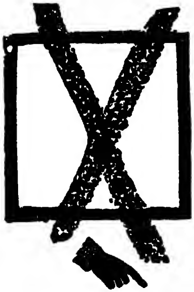

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